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Functional response of assassin bug, *Rhynocoris fuscipes* (Fabricius) (Hemiptera: Reduviidae) to cucumber leaf folder, *Diaphania indicus* Saunders (Lepidoptera: Pyraustidae)

K. Nagarajan, K. Rajan and **D.P. Ambrose***

Entomology Research Unit, St.Xavier's College, Palayankottai 627 002, Tamil Nadu, India
Email: eruxavier@gmail.com

ABSTRACT: The assassin bug, *Rhynocoris fuscipes* (Fabricius) exhibited Holling's type II curvilinear functional response to the cucumber leaf folder, *Diaphania indicus* Saunders. The predator's attack rate increased as the prey density increased. The maximum predation represented by 'k' value (2.30) was found at higher prey density. But the highest attack ratio (y/x) (0.99) was obtained at 1 prey/predator density and the lowest attack ratio (0.52) at 8 prey/predator density. There was a positive correlation between prey density and prey killed and a negative correlation between prey density and searching time of predator at all prey densities. At high prey density, predator spent less time in searching, therefore it spent more time in handling, whereas at low prey density the searching time was always found greater than the handling time. Handling time varied due to factors such as speed of pursuit of predator and prey escape or prey capture success. © 2010 Association for Advancement of Entomology

KEYWORDS: attack ratio, *Diaphania indicus*, functional response, handling time, Reduviidae, *Rhynocoris fuscipes*

INTRODUCTION

Generalist insect predators like assassin bugs are often expected to be important for controlling pests in agricultural systems (Altieri, 1995). The intuitive prediction is that increasing the density of generalist predators in a crop should increase predation on pests (Chang and Kareiva, 1999). The interest in Reduviidae as biological control agents has been highlighted by several authors (Ambrose, 1999; Grundy and Maelzer, 2002). *Rhynocoris fuscipes* (Fabricius) is a potential heteropteran predator inhabiting

*Present address: Department of Plant Biology and Biotechnology, St.Joseph's College, Trichy 620 002, Tamil Nadu, India

*Corresponding author

diverse agroecosystems (Ambrose and Claver, 2001). Although *R. fuscipes* is a generalist predator, it exhibits prey preference for soft bodied lepidopteran larvae followed by termites, bugs and beetles (Ambrose, 1999). The biological potential of *R. fuscipes* on many agricultural pests was studied (Ambrose, 1999), but no report is available on its biocontrol potential against the cucumber leaf folder, *Diaphania indicus* Saunders. *D. indicus* primarily attacks cucurbitaceae such as water melon, pumpkin, snake gourd and bitter gourd and also other plants viz., cotton and pigeon pea (CABI, 1998). Hence, an attempt was made to understand the biocontrol potential of this predator on *D. indicus*.

MATERIALS AND METHODS

A laboratory culture of *R. fuscipes* (Fabricius) was maintained in the laboratory (30–35 °C, 75–80% RH, 11–13 h photoperiod) on head crushed larvae of rice meal moth, *Corcyra cephalonica* (Stainton). Larvae of *Diaphania indicus* were collected from fields and maintained on fresh cucumber leaves in the laboratory.

The prey, *D. indicus* were first introduced into plastic containers of uniform size and were allowed to settle. After 10 min the predators were introduced at densities of 1, 2, 4 and 8 prey/predator. The prey number was maintained constant by replacing the dead larvae by live ones. Six replicates were maintained for each prey density. The preys consumed or killed were recorded daily at 24 h intervals for six days.

The functional response was worked out following the methods of Holling (1959). Regression analysis was done to determine the relationship between the prey density and the prey consumed, searching time and attack ratio.

RESULTS AND DISCUSSION

Table 1 shows the cumulative functional response of *R. fuscipes* to *D. indicus*. Most predators consumed all or most of the prey provided at lower prey densities and showed a deceleration in the rate of predation, with greater variation at higher prey densities and exhibited Holling's type II curvilinear functional response. This was confirmed by the positive correlation between prey densities and prey killed ($y = 0.6413 + 0.2096x$; $r = 0.9834$). Similar functional response was observed for other reduviids by Ambrose (1999), Ambrose *et al.* (2000), Claver *et al.* (2004) and Ravichandran *et al.* (2003).

A positive relationship between prey density and predation rate is often assumed to imply that predation is stabilizing. Accelerating functional responses, which are more typical of generalist than specialist predators, can result in density-dependent predation (Murdoch and Oaten, 1975). However, as Sinclair *et al.* (1998) argued, generalist predators like *R. fuscipes* are more likely than specialists to cause prey extinction because they may remain abundant despite scarcity of a particular prey species. Moreover, the functional response is also affected by the experimental conditions viz., time of exposure, age of predators, shape and dimension of arena, species of plant used during the exposure and temperature (Bhatt and Singh, 1991). In

TABLE 1. Cumulative functional response of adult *Rhynocoris fuscipes* to *Diaphania indicus*

Prey density (x)	Prey attacked (y)	Max y' (k)	Days/y $(b = Tt/k)$	All Y's days (by)	Searching $(Ts = Tt - by)$	Attack ratio (y/x)	Rate of discovery $[(y/x)/Ts = a]$	Disc equation $y' = a(Tt - by)$
1	0.72			1.87	5.01	0.99	0.19	
2	1.22	2.3		3.17	4.48	1.52	0.33	
4	1.47		2.6	3.82	3.10	2.90	0.93	$y' = 1.45(6 - 2.6by)x$
8	2.30			5.98	0.02	0.52	—	
$\bar{x}$							1.45	

$(n = 6)$

addition, accelerating functional response can result from predators switching among alternative prey types, selectively foraging in patches of high prey density, or learning through experience (Holling, 1959).

Another important component of functional response is the attack rate. The predator's attack rate/consumption rate increased in relation to prey density, and the highest (2.3) and the lowest attack rates (0.72) were observed at 8 prey density and 1 prey density, respectively. The attack rate is governed by several component parameters, such as the rate of prey encounter, the probability that the prey will be attacked when encountered and the probability that an attack will result in capture (Getty and Pulliam, 1991; Cogni *et al.*, 2002). Environmental complexity i.e., refuges and prey species can also influence the attack rate and reduce the efficacy of biological control agent (Hawkins *et al.*, 1993). Increased prey consumption at higher prey density might also due to different phenomena operating simultaneously in a predator's arena viz., searching time, prey density and predator satiation. *R. fuscipes* took 2.6 min to handle a *D. indicus* larva. Hunger level and time spent by the predator in searching and handling prey, i.e., pursuing, subduing and consuming the prey and then preparing itself for further search affect the prey consumption. Increase in handling time, an important component of functional response, leads to a decreased attack rate (Holling, 1959). At higher prey density reduction of unsuccessful attacks of predator on prey, due to less chances of escape takes place when compared to those in scarce prey density, where there are more chances for the prey to escape from the predator. Handling time was also influenced by the prey deprivation period of the predators; hunger is known to increase the prey handling time (Ray, 2008). Flinn *et al.* (1985) reported that handling time is proportional to the size of the prey because the predator takes a longer time to eat larger prey. This difference leads to a change in the maximal theoretical number of prey that could be eaten per unit of time. The maximum predation represented by 'k' value was always found restricted to higher prey density ($k = 2.3$), because higher prey density enabled the predators to spend less time to search its food and to utilize all its time in attacking and consuming the prey. Fig. 1 (Holling's type II curve) shows a steep rise in predation at 1 to 8 prey density. Morris (1963) reported that such type II curve is generally found in most heteropteran predators. In *R. fuscipes* the highest (0.99) and lowest (0.52) attack ratios were observed at 1 prey/predator and 8 prey/predator densities, respectively. It is presumed that the predator spent less time on searching activities at higher prey density, which in turn might have caused a perceptive decline in the attack ratio until hunger was established.

Negative correlation was obtained between prey density and searching time of predator ($Y = 5.86 - 0.722x; r = -0.9986$). Probability of the predator's higher prey contact at higher prey density would have enhanced the searching ability per unit area. In addition, satiation is a possible reason for decreased prey consumption at higher prey densities.

A negative correlation was obtained between the prey density and rate of discovery ($Y = 0.4757 - 0.0302x; r = -0.2524$). Similar results were found in *Rhynocoris*
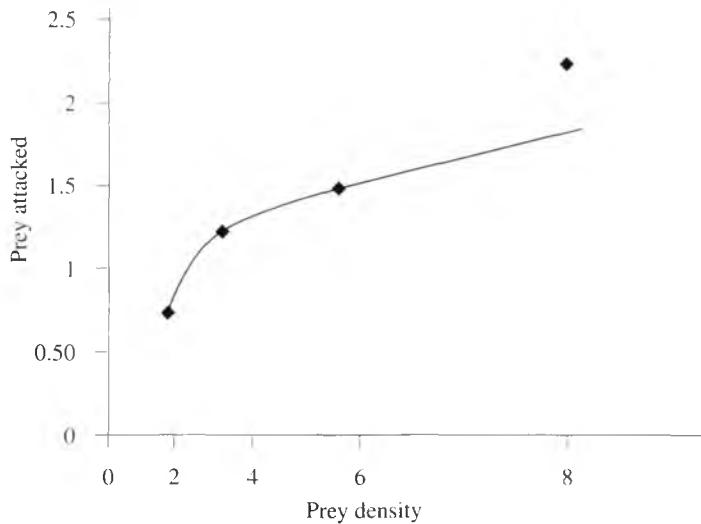
FIGURE 1. Cumulative curvilinear functional response curve of adult *Rhynocoris fuscipes* to *Diaphania indicus*.

fuscipes (Fabricius) to three pests of pigeon pea (Claver and Ambrose, 2002) and *Rhynocoris longifrons* Stål to *Clavigralla gibbosa* Spinola (Claver *et al.*, 2002). In contrast, a positive correlation was obtained between prey density and rate of discovery in *Rhynocoris marginatus* (Fabricius) to *Spodoptera litura* Fabricius (Ambrose and Claver, 1995), in *Acanthaspis siva* Distant to *Componotus compressus* Fabricius and *Dittopternis venusta* Walker (Ambrose *et al.*, 1994) and in *Coranus spiniscutis* (Reuter) to tomato insect pests (Claver *et al.*, 2004).

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B. K. Agarwala and Parna Bhadra

Ecological and biological characteristics of two forms of *Pentalonia nigronervosa* Cocquerel f. *typica* and f. *caladii* (Hemiptera: Aphididae)

B.K. Agarwala* and Parna Bhadra

Ecology and Biodiversity Laboratories, Department of Zoology, Tripura University, Suryamaninagar 799 130, Tripura, India
Email: bkagarwala54@yahoo.co.in

ABSTRACT: Natural populations of banana aphid, *Pentalonia nigronervosa*, is known to occur in two forms based on morphological differences, (i) f. *caladii* from cardamom and taro host plants and (ii) f. *typica* from banana host. In biological characters, apterous morph of f. *caladii* from taro host plants were more fecund, showed higher net reproductive rate, longer reproductive duration, and longer adult longevity than f. *typica* aphids from banana host plants. In ecological characters, f. *caladii* formed bigger colonies in significantly less time in comparison to f. *typica* aphids which formed smaller colonies. Reciprocal host plant transfer experiments showed that the performance of taro clones when transferred to banana plants significantly declined and banana clones when transferred to taro plants showed improved performance on transferred plants. Results indicate the occurrence of two forms of *P. nigronervosa* in relation to host plant utilization and strongly suggested that f. *caladii* from taro is a specialist genotype whereas f. *typica* from banana is more generalist. © 2010 Association for Advancement of Entomology

KEYWORDS: banana aphid, two forms, ecological characters, biological characters

INTRODUCTION

Insect species show considerable variations in morphology, biology and ecological parameters within their populations (Singh and Cunningham, 1981; Helden *et al.*, 1994; Powell *et al.*, 2006). Often this can cause problem in the accurate separation of taxa at species and infra-species levels (Miyazaki, 1987; Agarwala and Ghosh, 1985). The suggested methods to discriminate intra-specific populations include study of karyotype and morphology (Eastop and Blackman, 1987), morphology and ecology (Guldemond *et al.*, 1994; Watt and Hales, 1996), gel electrophoresis of proteins and enzymes (Loxdale, 1990; Agarwala *et al.*, 2002, 2007) and random amplified

*Corresponding author

polymorphic DNA-polymerase chain reaction (RAPD-PCR) (Lushai *et al.*, 1997). Gorur *et al.* (2005, 2007) recorded genotypic variability and phenotypic plasticity in *Aphis fabae* Scopoli when reared on preferred host as well as on novel host.

Eastop (1966) reported the occurrence of two forms of *P. nigronervosa* based on morphological differences from Australia: (i) *P. nigronervosa* f. *caladii* van der Goot from plants of Araceae and (ii) *P. nigronervosa* f. *typica* Eastop from plants of Musaceae. Siddappaji and Reddy (1972) reported that the aphids occuring on banana plants in parts of South India belong to the form *typica*, and those infesting cardamom and taro plants belong to the form *caladii*. The objective of this study was to record biological and ecological characteristics of the two forms of *P. nigronervosa*. Reciprocal host plant transfer experiments were also performed to ascertain specificity of the two forms to their respective host plants.

MATERIALS AND METHODS

Apterous parthenogenetic viviparous aphids of *P. nigronervosa* were collected from banana and taro plants distributed in rural agricultural locations of Agartala, north–east India (23.50° N latitude and 91.25° E longitude). These aphids were used in the stock culture and were maintained on their respective hosts planted in pots and maintained under greenhouse conditions. A single fourth instar wingless aphid collected from the stock culture was released on a 16–20 day old host plant raised in plastic pot. Several such plants were set up for each host plant. These were allowed to grow, reproduce and increase in number. Aphid cultures on individual potted plants were segregated by nylon net cages. All aphids produced from a single mother on each plant were of same genotype and thus constituted a clone. Several such clones were raised for *P. nigronervosa* f. *caladii* and *P. nigronervosa* f. *typica* on their respective host plants raised in pots singly. Females of the progeny were again transferred singly on potted plants of the two hosts and were allowed to grow and breed. Three consecutive generations were reared adopting the same method in the laboratory on respective host plants. Simultaneously, *P. nigronervosa* f. *typica* were reared on individual taro plants and *P. nigronervosa* f. *caladii* on banana plants for three successive generations in reciprocal host transfer experiment.

The biological parameters of development in the two forms of *P. nigronervosa* on their original hosts and on hosts interchanged were assessed in the fourth generation. Third generation fourth instar nymphs were individually transferred to cages made out of single detached leaves of the respective host plants following the methods of Blackman (1987). Twenty replicates were maintained for each of the two hosts and their reciprocals. From the time of moulting of the nymphs they were continuously monitored for recording the various developmental parameters. The parameters recorded were birth weight, adult weight, development time, generation time, reproductive duration, adult longevity and fecundity. From the data, net reproductive rate (R_0) and intrinsic rate of increase (R_{max}) were calculated adopting the formulae of Krebs (1985), and mean relative growth rate was calculated by the formula of Watt and Hales (1996).

The ecological parameters of growth in the two forms of *P. nigronervosa* on their original hosts and on hosts interchanged were assessed in the fourth generation. Third generation fourth instar nymphs were individually transferred to potted plants following the method of Agarwala *et al.* (2007). Twenty replicates were maintained for each of the two hosts and their reciprocals. Individual plants were monitored for increase in number of aphids at 24 h interval and maximum size of population was recorded. The parameters recorded were population growth rate (GR), carrying capacity (K) and time to achieve K (T_k). The GR, K and T_k were calculated adopting the formulae of Odum (1971), Stiling (2006) and Agarwala *et al.* (2009), respectively.

Data collected in the experiment were subjected to analysis of variance and the effect of the two hosts and their reciprocals on different parameters were compared with Tukey's multiple range test.

RESULTS

Biological parameters

The two forms of *P. nigronervosa* from taro and banana plants, respectively, showed significant differences in developmental time, generation time, and fecundity (Table 1); f. *caladii* was 2.24 times more fecund and showed higher net reproductive rate on taro plants than f. *typica* on banana plants. The two forms of *P. nigronervosa*, however, did not show difference in intrinsic rate of increase.

Ecological parameters

The *P. nigronervosa* f. *caladii* clones showed a mean growth rate of 2.73 aphids/day which was 3.14 times higher compared to the *P. nigronervosa* f. *typica* clones. Mean carrying capacity of taro plants for f. *caladii* clones was 341.89 aphids per plant which was higher by 4.27 times compared to the carrying capacity of banana plants for f. *typica* clones. However, time taken by f. *caladii* and f. *typica* clones to achieve the carrying capacity on respective host plants did not show the same trend. Aphids of f. *caladii* clones on taro plants reached the peak population in 29.2 days in comparison to 42.8 days taken by f. *typica* clones reared on banana plants. Thus, *P. nigronervosa* f. *typica* on banana plants formed smaller colonies in more time in comparison to f. *caladii* clones on taro plants which formed bigger colonies in less time (Table 1).

Reciprocal host transfer

Results obtained from reciprocal host transfer experiments are presented in Table 1. In biological parameters, f. *caladii* showed shorter developmental time, shorter reproductive time, lower fecundity, longer adult longevity, lower intrinsic rate of increase, and lower mean relative growth rate on transferred banana host than on taro host. However, f. *typica* showed longer generation time, lower reproductive time, higher fecundity, higher net reproductive rate and higher mean relative growth rate on transferred taro plant than on banana host. In ecological parameters, f. *caladii* showed slower rate of population growth, decreased carrying capacity and took longer time to

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TABLE 1. Biological and ecological parameters of fourth generation apterous *P. nigronervosa* f. *typica* and f. *caladii* reared on banana and taro hosts and on reciprocal transferred hosts.

Parameter	f. *typica*		f. *caladii*	
	Banana	Taro (host transferred)	Taro	Banana (host transferred)
Biological Parameters				
BW (mg)	0.02 ± 0.002^a	0.02 ± 0.001^a	0.03 ± 0.001^b	0.03 ± 0.001^b
AW (mg)	0.27 ± 0.006^a	0.26 ± 0.0^a	0.27 ± 0.02^a	0.26 ± 0.009^a
DT (days)	8.25 ± 0.11^a	8.55 ± 0.16^a	10.05 ± 0.20^b	7.85 ± 0.38^a
GT (days)	9.45 ± 0.17^a	14.45 ± 0.24^b	11.35 ± 0.25^c	12.85 ± 0.22^c
RD (days)	9.60 ± 0.37^a	7.95 ± 0.56^a	13.50 ± 0.97^b	3.00 ± 0.31^c
AL (days)	12.85 ± 0.40^a	12.25 ± 0.62^a	16.25 ± 1.15^b	6.55 ± 0.49^c
F (number)	10.90 ± 0.38^a	15.00 ± 1.38^b	24.50 ± 1.11^c	8.50 ± 0.64^a
R_0 (aphid no./female/GT)	10.71 ± 0.66^a	16.43 ± 1.51^b	24.56 ± 0.90^c	21.71 ± 1.96^c
R_{max} (aphid no./mother/day)	0.21 ± 0.007^a	0.22 ± 0.04^a	0.20 ± 0.02^a	0.18 ± 0.015^b
MRGR (mg mg^{-1} d^{-1})	0.11 ± 0.002^a	0.22 ± 0.03^a	0.10 ± 0.003^a	0.08 ± 0.002^a
Ecological parameters				
ΔGR (increase in aphid no./day)	0.87 ± 0.118^a	2.64 ± 0.08^b	2.726 ± 0.349^b	0.414 ± 0.05^c
K (number)	80.09 ± 7.667^a	108.69 ± 3.91^b	341.89 ± 38.98^c	26.89 ± 3.09^d
T_k (days)	42.80 ± 2.23^a	40.00 ± 2.15^a	29.20 ± 1.466^b	34.00 ± 1.79^b

Values given are Mean $\pm$ SEM.
Values with different letters in a row denote significant differences between them by Tukey's multiple range test at $P < 0.05$.
BW, birth weight; AW, adult weight; DT, development time; GT, generation time; RD, reproductive duration; AL, adult longevity; F, fecundity; R_0, net reproductive rate; R_{max}, intrinsic rate of increase; MRGR, mean relative growth rate; GR, population growth rate; K, carrying capacity; T_k, time to achieve K.

achieve the carrying capacity on the transferred banana than on taro plants. In contrast, f. *typica* showed higher rate of population growth, increased carrying capacity and took shorter time to achieve the carrying capacity on the transferred taro plants than on banana plants.

DISCUSSION

Eastop (1966) distinguished f. *typica* and f. *caladii* on the basis of morphological difference in winged viviparous morph. The present study has shown that wingless viviparous morph of the two forms of *P. nigronervosa* also showed consistent, significant differences in biological and ecological characters. In biological characters, *P. nigronervosa* f. *caladii* showed higher fecundity, higher net reproductive rate, longer reproductive duration and adults lived longer on taro plants than the f. *typica* on banana plants. In ecological characters, *P. nigronervosa* f. *caladii* formed bigger colonies in significantly less time on taro plants in comparison to f. *typica* on banana plants which formed smaller colonies in more time. In reciprocal host transfer experiments, f. *caladii* aphids showed lower developmental and reproductive fitness and decreased growth rate on transferred banana plants but f. *typica* aphids showed higher fecundity, longer reproductive period, increased growth rate and higher carrying capacity on transferred taro plants.

Results suggested that f. *typica* and f. *caladii*, both, performed better on taro plants, but f. *caladii* performed poorly on banana plants. Thus, f. *caladii* showed host specialization on taro plants whereas f. *typica* showed wider choice of host plants. Populations of *P. nigronervosa* have also been reported from cardamom, ginger, *Heliconia* spp., *Caladium* spp., *Alpinia* spp. and *Dieffenbachia* spp. from different parts of the world (Blackman and Eastop, 1984). In future studies it would be interesting to know whether aphids from these host plants belong to f. *typica* or f. *caladii* or to some unknown form.

Several studies on insect herbivores have found significant intra-specific variations in relation to host plant utilization (Futuyama and Philippi, 1987; Via, 1990). Intra-specific variation can be caused either by genetic differences or by the effects of experience on tested host plants (Lowe, 1973; Via, 1991; Gorur *et al.*, 2005). Between f. *typica* and f. *caladii* tested in this study, the *typica* genotype expressed lower fitness on banana host plant than the *caladii* genotype on taro host plant. Such a difference in response to host plants is suggestive of strong genotype (aphids)-environment (host plants) interactions which indicate the occurrence of increased genetic variations in natural populations. The hypothesis of sympatric speciation in phytophagous insects including aphids occurring via phenotypic host race formation has been gaining acceptance in recent years (Gorur, 2000; Agarwala and Das, 2007; Agarwala *et al.*, 2007, 2009). Result of this study has contributed to our understanding as to how phenotypic plasticity in an insect species facilitates speciation (Agarwala, 2007; Gorur *et al.*, 2007).

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P. D. Kamala Jayanthi *et al.*

Feeding attractants as a component for integrated management of fruit sucking moth, *Eudocima (Othreis) materna* (L.) (Lepidoptera: Noctuidae)

P. D. Kamala Jayanthi*, **A. Verghese, D. K. Nagaraju and B. Jhansi Rani**

Division of Entomology and Nematology, Indian Institute of Horticultural Research, Hesseraghatta Lake P.O., Bangalore 560 089, India
Email: jaiinsect@yahoo.co.in

ABSTRACT: This paper deals with the results of choice feeding tests of fruit sucking moth, *Eudocima [Othreis] materna* (L.) on pomegranate/guava fruits using different feeding attractants. The moth preference for feeding attractants differed with the type of test fruit used. Nevertheless, the percent attraction over untreated control showed that crushed juice of pomegranate, arrack and molasses were comparatively more effective. Implications of the results for development of new lures for controlling *E. materna* populations are discussed. © 2010 Association for Advancement of Entomology

KEYWORDS: *Eudocima [Othreis] materna*, fruit sucking moth, pomegranate, *Punica granatum*, guava, *Psidium guajava*, attractants

INTRODUCTION

The fruit sucking (=piercing) moth, *Eudocima [Othreis] materna* (L.) (Lepidoptera: Noctuidae) attacks wide variety of commercially important crops such as pomegranate, citrus, guava, mango, papaya, litchi, carambola, grapes, eggplant and tomato (McDaniel, 1971; Sundarababu and David, 1973; Godfrey and Jah, 1975). Moths feed at night by penetrating the skin of the ripe or ripening fruit with their strong proboscis and sucking the juice. Internal injury consists of a bruised dry area beneath the skin and secondary rots develop at the puncture site (Atachi *et al.*, 1989). Further, secondary-moth feeders taking advantage of the access hole drilled by *E. materna* feed on the fruits first attacked by the pest. An individual moth may attack a number of fruits in a single night.

It is difficult to control the pest since the immature stages live only on vines (Family *Menispermaceae*) in scrub and forest areas, often far from orchards (Fay, 1996).

*Corresponding author

Although the orchards close to breeding areas are at greater risk of damage, moths are known to migrate long distances and cause very severe damage to cultivated fruit plants. Insecticidal control, night watching, hand collection of moths, moth destruction using light traps, bonfires and altering cropping period are being adopted to control the damage, often with limited success. Evaluation of chemical baits against *E. materna* gave varying results in fruit moths (Bŝziger, 1982; Kumar and Lal, 1983). The aim of the present study was to assess the relative efficacy of some feeding attractants to *E. materna* with a view to developing some effective lures.

MATERIALS AND METHODS

The study was carried out at the Division of Entomology & Nematology, Indian Institute of Horticultural Research (IIHR), Bangalore, India. An initial comparison of twelve different baits along with an untreated control was carried out using two different fruits viz., pomegranate (*Punica granatum* L.) and guava (*Psidium guajava* L.) as base to hold the attractants.

The larvae of *E. materna* collected from the vines of *Tenospora cordifolia* L. were cultured in the laboratory following the methods of Bhumannavar and Viraktamath (2001). From this culture, 10–15 days old moths were selected for the experiments. The attraction of *E. materna* towards different treatments was studied under laboratory conditions at $28 \pm 1 \,^\circ C$. To accommodate all treatments and to provide enough flying space to moths a walk-in indoor-screened enclosure (hereafter called net house) was used for carrying out the experiment with an arena of a $38''$ height $\times$ $49.5''$ width $\times$ $69''$ length.

Twelve attractants were evaluated in the experiment (Table 1). For first six treatments 20 g of material was mixed in 200 ml of sterile distilled water and for remaining six treatments, 1 ml each was mixed in 100 ml of sterile distilled water and for all treatments an adjuvant APSA-80 @0.3 ml/l was also added. Guava and pomegranate fruits were dipped in the respective treatments ensuring that the entire surface of each fruit could get uniform coating. An untreated control was also kept. Each treatment was replicated thrice. The fruits were hung from the roof of the net house 1m apart at random. The treated fruits were exposed to 50 pairs of *E. materna* moths for over night and in the morning, the fruits were removed from the cage and the number of feeding holes per fruit was counted. The data were transformed in to $\sqrt{x} + 1$ values and subjected to one-way analysis of variance (ANOVA) and DMRT was used for the comparison of means (Little and Hills, 1978).

RESULTS AND DISCUSSION

In this study, varieties of feeding attractants (commercial fruit flavors, natural fruit juices, larval host plant extract, sugar and alcohol based) were compared in choice test using pomegranate and guava fruits as base.

TABLE 1. Relative efficacy of selected attractants on *E. materna* on guava/pomegranate

Attractant tried	Number of feeding holes observed on					
	Guava			Pomegranate		
	Expt. I	Expt. II	Mean	Expt. I	Expt. II	Mean
Tenospora leaf	6.00^b	8.00^b	7.00^b	4.00^b	11.50^{ab}	7.75^b
extract	(2.30)	(3.00)	(2.65)	(2.22)	(3.11)	(2.66)
Crushed	32.50^{ab}	41.50^a	37.00^a	6.50^b	15.00^{ab}	10.75^{ab}
pomegranate	(5.76)	(6.33)	(6.05)	(2.74)	(3.72)	(3.23)
Crushed guava	23.50^{ab}	8.50^a	16.00^b	1.50^b	14.00^{ab}	7.75^b
(Infested)	(4.85)	(2.94)	(3.89)	(1.50)	(3.86)	(2.68)
Crushed guava	39.00^{ab}	16.50^a	27.75^{ab}	10.00^{ab}	11.00^{ab}	10.50^{ab}
(Healthy)	(6.32)	(4.17)	(5.25)	(3.31)	(3.46)	(3.39)
Jaggery	30.00^{ab}	14.00^{ab}	22.00^{ab}	14.00^{ab}	27.00^a	20.50^a
	(5.30)	(3.82)	(4.56)	(3.86)	(5.24)	(4.55)
Molasses	16.50^{ab}	39.00^a	27.75^{ab}	21.00^{ab}	16.00^{ab}	18.50^a
	(4.08)	(6.32)	(5.20)	(4.68)	(4.06)	(4.37)
Mango essence	3.00^b	8.50^b	5.75^b	25.00^a	12.50^{ab}	18.75^a
	(1.98)	(2.62)	(2.30)	(5.05)	(3.67)	(4.36)
Orange essence	8.50^b	0.50^b	4.50^b	7.50^b	0.00^b	3.75^b
	(2.77)	(1.21)	(1.99)	(2.85)	(1.00)	(1.93)
Strawberry	24.50^{ab}	15.50^{ab}	20.00^{ab}	16.50^{ab}	17.50^{ab}	17.00^{ab}
essence	(4.99)	(4.00)	(4.50)	(4.17)	(4.23)	(4.20)
Grape essence	16.50^b	20.50^{ab}	18.50^{ab}	9.50^b	3.00^b	6.25^b
	(3.42)	(4.63)	(4.02)	(2.99)	(1.98)	(2.49)
Vinegar	4.50^b	4.00^b	4.25^b	2.00^b	4.00^b	3.00^b
	(2.34)	(2.12)	(2.23)	(1.62)	(2.19)	(1.90)
Arrack	54.00^a	25.00^{ab}	39.50^a	2.50^b	18.00^{ab}	10.25^{ab}
	(7.35)	(4.89)	(6.12)	(1.72)	(4.35)	(3.03)
Control	21.50^{ab}	16.50^{ab}	19.00^{ab}	2.50^b	7.00^b	4.75^b
	(4.28)	(4.18)	(4.23)	(1.72)	(2.78)	(2.25)
Total	280.00	218.00	249.00	122.49	156.50	139.50
(Mean)	(21.53)	(16.77)	(19.15)	(9.42)	(12.04)	(10.73)

The values given are mean of three replications.

Figures in parentheses are $\sqrt{x+1}$ transformed values.

In each column, figures superscribed by the same alphabet do not differ significantly at 5 per cent level of significance.

Pomegranate as test fruit

In the first choice test (where the moths had free access to choose from all the 12 treatments), mango essence, a commercial fruit flavor was found to be significantly superior (Table 1) to untreated control in attracting *E. materna* as evident by maximum number of feeding holes per fruit (25.00). This treatment was found to be statistically on par (Table 1) with other molasses. (21.00), strawberry essence (16.50), jaggery

(14.00) and healthy ripe guava juice (10.00). However, except mango essence, the rest of the treatments were on par to the control.

In the second test, significantly, the highest number of feeding holes was observed in fruits treated with jaggery (27.00 per fruit) and it was on par with arrack (18.00), molasses (16.00), strawberry essence (17.50), mango essence (12.50), guava juice-H (11.00), guava juice-I (14.00), pomegranate juice (15.00) and *Tenospora* leaf extract (11.50). However, except jaggery, all the remaining treatments were also on par to the untreated control.

A perusal of means showed that fruits dipped in jaggery (20.50), mango essence (18.75), and molasses (18.50) were significantly preferred by *E. materna*. However, strawberry essence (17.00), pomegranate juice (10.75), guava juice-H (10.50) and arrack (10.25) were also found to be equally attractive and significantly on par with the above.

Guava as test fruit

None of the attractants appeared to act as potent feeding stimulants as the number of feeding holes in treatments were on par with untreated control (Table 1).

The results clearly indicate that among fruit based attractants mango and strawberry essence were effective in attracting the moths, but did well when pomegranate was used as test fruit. None of the commercial fruit flavors were found effective in attracting the moths to guava fruits. This may be because of natural aroma of ripe guava fruit, which would have dominated the commercial applied flavors. Since the pomegranate is a hard skinned fruit without aroma, the commercial flavors worked well with that fruit. Interestingly, the crushed juice of ripe pomegranate was also found more attractive for moths with guava as test fruit than pomegranate. Nevertheless, the juice of healthy ripe guava was found to be consistently attractive to *E. materna* moths irrespective of test fruit. Further, guava juice from fruit sucking moth-damaged fruits was not found superior over healthy ripe guava juice in attracting fruit sucking moth as thought earlier. Here the clue was taken from Baptist (1944) who mentioned that the odours emanating from the attacked/spoiled fruit can serve as an attractant for the moths, hence regular collection and proper disposal of all attacked and spoiled fruits on ground as well as on tree would reduce damage.

The larval food plant, *Tenospora cordifolia* leaf extract also did not attract the moths on contrary to Fujimura (1972) studies, who found that exudates and extracts of larval food plant *Coculus trilobus* and *Sinomenius acutum* were effective for 1–2 nights in preventing *Oraesia excavata* and *Adris tyrannus amurensis* from piercing the peaches.

Among the sugar based attractants, molasses was found to be powerful attractant and induced greatest response by fruit sucking moth. However, jaggery was found highly attractive with pomegranate, but did not work well for guava. Boscan-de-Martinez *et al.* (1981) observed significant positive correlation between the numbers of Lepidoptera caught and the concentration of molasses.

Of alcohol-based attractants tried, arrack (country liquor) was found extremely attractive to moths with guava compared to pomegranate. Yoon and Kim (1977) found

that an attractant named *takju* (thick unrefined liquor fermented from grains) with honey, brown sugar, vinegar or peach or grape juice attracted the largest number of fruit sucking noctuids. However, in the present study vinegar was found to be completely non-attractive over untreated control.

Testing feeding attractants on two different fruits *viz.*, pomegranate and guava further indicated that choice of feeding attractants might depend on the type of crop, as fruit sucking moth response for some feeding attractants was found quite different in pomegranate (hard rind) and guava (soft skin). Jaggery, mango and strawberry essences exhibited encouraging results in attracting *E. materna* only when pomegranate was used as test fruit, so their use may be recommended in pomegranate. Likewise, juice of crushed pomegranate and arrack were found effective only when guava was used as test fruit. This result indicates that care must be emphasized in choosing feeding attractants for different crops.

The present study is a first step in exploring potential feeding attractants for *E. materna*. Expectations of feeding preference were frequently contradicted with types of test fruit and attractant. Molasses was invariably the most preferred irrespective of test fruits used, and may act as a useful ingredient of bait formulations for *E. materna*. None of the other attractants elicited the same pattern of response. However, jaggery, arrack, ripe guava and pomegranate juices were also found equally attractive to fruit sucking moths. Further, the commercial fruit flavors like mango and strawberry essences were found to be powerful attractants for fruit sucking moth in pomegranate. The materials identified in the present study may provide sources of developing attracticidal approaches to suppress *E. materna* populations.

With the exception of some attractants (takju) evaluated by Yoon and Kim (1977), no other attractants have been so far identified for *E. materna*. For large-scale growers, producing fruit for export markets commercially available baits are recommendable. The information on the optimum concentration, combined application of different attractants and shelf life of baits would be of use to isolate and identify attractive volatile elements emanating from effective baits. Although, the present study indicates the use of different attractants in attracting the fruit sucking moth, these attractants may perform differently in natural populations than would seem apparent from laboratory experiments. More detailed studies and field trials with a range of these experimental feeding attractants are warranted to offer growers a practical means to control this obnoxious insect pest.

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Description of two new species of *Apanteles* Foerster (Hymenoptera: Braconidae: Microgastrinae) from Chhattisgarh, India

Mohd. Yousuf* and Puja Ray

Forest Entomology Division, Tropical Forest Research Institute, Jabalpur 482 021, Madhya Pradesh, India
Email: yousuf_tfri@yahoo.com

ABSTRACT: Two new species, *Apanteles neocajani* and *A. neotaeniaticornis* are described and illustrated. Type specimens of *A. neocajani* had emerged from larvae of *Euproctis* sp., infesting *Lagerstroemia parviflora* Roxburgh and type specimens of *A. neotaeniaticornis*, from a defoliator (undetermined moth) of *Acacia nilotica* (L.) Willd. ex Delile. The new species are compared with their closely related species, *A. cajani* Wilkinson and *A. taeniaticornis* Wilkinson, respectively.
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KEYWORDS: *Apanteles neocajani*, *A. neotaeniaticornis*, Braconidae, Hymenoptera, Microgastrinae

INTRODUCTION

The parsasitic wasps belonging to genus *Apanteles* Foerster (Hymenoptera: Braconidae) are important larval parasitoids of several key insect pests of agricultural crops, commercial cash crops and forest tree species. *Apanteles* belongs to subfamily Microgastrinae, the most conspicuous single group of endoparasitoids of Lepidoptera in the world, both in species richness and economic importance (Whitfield, 1997). The genus *Apanteles* was erected by Foerster (1862) and has since then been studied by several authors (Wilkinson, 1928a,b; Nixon, 1967; Mason, 1981; Papp, 1987). Several authors (Rao, 1961; Sharma, 1972, 1973; Sathe and Inamdar, 1989; Sumodan and Sevichan, 1989; Sumodan and Narendran, 1990; Sathe and Ingawale, 1995; Kurhade and Nikam, 1997) have studied the Indian species of *Apanteles*.

In the present work two new species of *Apanteles* are described and illustrated. The type specimens of *Apanteles neocajani* had emerged from the larvae of *Euproctis* sp.,

*Corresponding author

infesting *Lagerstroemia parviflora* Roxburgh and the type specimens of *A. neotae-niaticornis*, from a defoliator (undetermined moth) of *Acacia nilotica* (L.) Willd. ex Delile.

<center>MATERIALS AND METHODS</center>

Systematic survey of various forests and agro-forestry areas of Chhattisgarh, India, was conducted to collect braconid parasitoids, their host larvae and plant samples with insect attack. Several pupae of *Apanteles neocajani* along with their host larvae of *Euproctis* sp. were collected from dense canopy of the host plant, *Lagerstroemia parviflora*. They were brought to the laboratory and attempts were made to rear the collected larvae of the *Euproctis* sp. on its host leaves. Similarly, pupae of *A. neotaeniaticornis* were collected from leaves of *A. nilotica* along with larvae of undetermined moth. The pupae were kept in the laboratory for parasitoid emergence. Braconids emerged from larvae and cocoons were collected and the species belonging to *Apanteles* identified. Morphological terminology (especially for wing venation) followed was that of modified Comstock–Needham system (Eady, 1968; Achterberg, 1979). Figures were drawn with the help of Camera Lucida attached to Stereoscopic, Trinocular (Labomed) Microscope and measurements were taken using Ocular Micrometer.

Abbreviations used: OOL — Ocello-ocular line (distance from the outer edge of a lateral ocellus to the compound eye); POL — post-ocellar line (distance between the inner edge of the two lateral ocelli); AOL — anterior-ocellar line (distance between the inner edge of anterior and lateral ocellus); ØOD — diameter of an ocellus.

Apanteles neocajani **sp. n.**

Female

Body length 2.6 mm (excluding ovipositor and antenna); Fore wings length 3.2 mm, antennal length 2.8 mm.

Colour: General body colour black, except legs beyond coxae, ovipositor, reddish yellow; hind tibia apically darkened; hind tarsi largely darkened; the fore coxae black but interrupted with reddish yellow colouration. Ocelli pale translucent with reddish tinge. Ovipositor sheath, stigma, metacarp, tergites, antenna, brown; wing venation light brown to hyaline; 1st abscissa of radius, transverse cubital and pigmented portion of the second abscissa of the cubital are dark brown; palpi and tibial spurs pale.

Head: In anterior view, length of head twice its width; OOL 1.5 times POL; latter twice ØOD and slightly less than AOL; malar space 2.2 times as long as mandibular base; face punctate, epistomal suture distinct and straight; antennae (Fig. 1A, B) filiform, with 16 flagellar segments and longer than body.
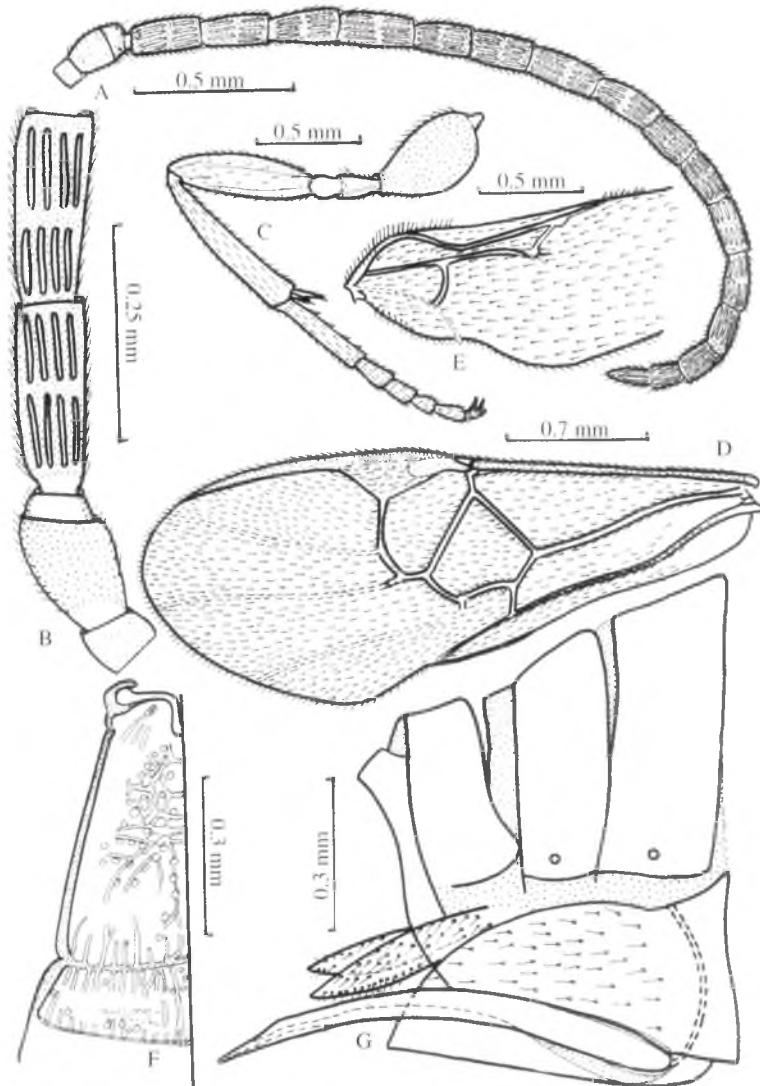
FIGURE 1. A–G. *Apanteles neocajani* sp. n. A, Antenna ♀; B, Antenna ♀ enlarged; C, Hind leg ♀; D, Fore wing ♀; E, Hind wing ♀; F, Metasomal tergites ♀; G, Abdomen with genitalia ♀.

Mesosoma: Pronotum laterally with a crenulated groove medially; mesoscutum finely and distinctly punctate; scutellum distinctly punctate. Fore wings (Fig. 1D) 2.5 times as long as their maximum width. Length of pterostigma about 2.5 times its breadth and shorter than metacarp: 1st abscissa of radial about 1.1 times as long as the breadth of pterostigma; stigmal breadth about 1.2 times as long as transverse

cubital; the latter just about 1.15 times as long as the apical portion of the 1st abscissa of the cubital. The pigmented portion of the 2nd abscissa of the cubital equal to the parastigma. Hind wing (Fig. 1E) about 4.3 times as long as its maximum width with vannal lobe large and flattened beyond its widest part. Propodeum about two times as broad as long (0.65 : 0.32 mm); more strongly sculptured anteriorly than posteriorly, with clearly carinated pentagonal areola that is open at anterior end with sculptures of group of round depressions. Transverse carinae laterally complete; spiracles separated from lateral propodeal margin by one–fourth of its own diameter. Hind-legs (Fig. 1C) with coxae finely punctate. The hind tarsal segments combined slightly longer than the length of the tibia and 1.3 times the length of the femur. Longer tibial spur two-fifth and shorter tibial spur one-third the length of hind basal tarsus.

Metasoma: Gaster shorter than head and thorax combined. First tergite (Fig. 1F) medially tumescent and lightly rugose with sparse punctation. First tergite about 1.2 times as long as its apical width and 1.5 times its basal width; second tergite with its basal width 3 times as long as its length. Second tergite longitudinally rugose, evenly punctate, weakly convex along its posterior margin. Apart from first and second, other tergites smooth with fine punctation. The ovipositor sheath (Fig. 1G) uniformly hairy and equal in length to the hind basal tarsus.

Male

Similar to female except the length of the antenna is equal to the length of the body, and in the hind legs longer tibial spur is about half the length of the hind basal tarsus.

Cocoon

White, elongated and cylindrical. 2.5 times as long as wide. The adult parasitoid emerged after cutting a circular lid at one end of the cocoon.

Holotype: ♀ India: Chhattisgarh, Kawardha (Borla) (latitude 22.02 °N, longitude 81.25 °E),17.VIII.2007, emerged from the larvae of *Euproctis* sp. infesting *Lagerstroemia parviflora*, collected by M. Yousuf.

Paratype: 6♀4♂, data same as holotype.
Holotype ♀ and 1♂ paratype have been deposited at National Forest Insect Collection, Entomology Division, Forest Research Institute, Dehra Dun, India (Acc. No. 21897).

Discussion

The new species, *A. neocajani* is very close to *A. cajani* Wilkinson (based on type material from type locality Ceylon). However it differs from the latter in being much nigrescent. Other differences in characters are given in the following key:

1. Female with first metasomal tergite about twice as broad at base as at apex and about 1.5 times as long down middle as the basal width; sides of first tergite somewhat more quickly converging to the truncated apex; male with antennae longer than the body length . . . . *A. cajani* Wilkinson.

2. Female with first metasomal tergite about 0.6 times as broad at base as at apex and about 2 times as long down middle as the basal width; sides of first tergite somewhat diverging to the apex; male with antennae about as long as body length. . . . . *A. neocajani* sp. n.

Apanteles neotaeniaticornis sp. n.

Female

Body length, 3.6 mm (excluding ovipositor and antenna); forewing length, 3.1 mm; antenna length, 3.1 mm.

Colour: Body brown to reddish brown; antennae brown, legs red testaceous, except apical one-third of hind femora and tibia, apical half of basitarsus and rest of the hind tarsi nigrescent; palpi and tibial spur pale, wings infumated, stigma, metacarp, wing veins and first metasomal tergite brown, second tergite and ovipositor red testaceous, ovipositor sheath reddish brown.

Head: In anterior view, length of head equal to its width. Face finely punctate. OOL 1.8 times the POL, the latter equal to ØOD and just more than the AOL; malar space about 2 times the mandibular base. Antennae (Fig. 2A, B) shorter than the body, nearly equal to the size of the fore wing, filiform with 16 flagellar segments.

Mesosoma: Mesonotum with regular and separate punctures; propodeum with very few sculptures posteriorly in the form of reticulation near the basal portion of areola; clearly carinated pentagonal areola with elongated base; areola opens anteriorly; spiracle separated from lateral propodeal margin by as much length as its diameter. Forewings (Fig. 2D) about 2.5 times as long as maximum breadth; 1st abscissa of the radial slightly curved, just shorter than the breadth of the stigma (9.5 : 10), its point of junction with the transverse cubital well-marked. The transverse cubital straight, about equal to the apical portion of the first abscissa of the cubital, rather longer than the upper portion of the basal vein. Stigma shorter than the metacarp. Hind wing (Fig. 2E) about 3.2 times as long as its maximum width. Vannal lobe slightly concave with a few setae. In the hind legs (Fig. 2C), coxae finely and evenly punctate except the outer face which is more or less bare; femur about 1.2 times the length of the coxa while the tibia is 1.3 times the length of the femur. Longer tibial spur three-fifth and shorter tibial spur about one-third the length of the hind basi-tarsus.

Metasoma: First metasomal tergite (Fig. 2F) about two times as long as its maximum breadth and three times of its apical width. Second tergite about 2.3 times as
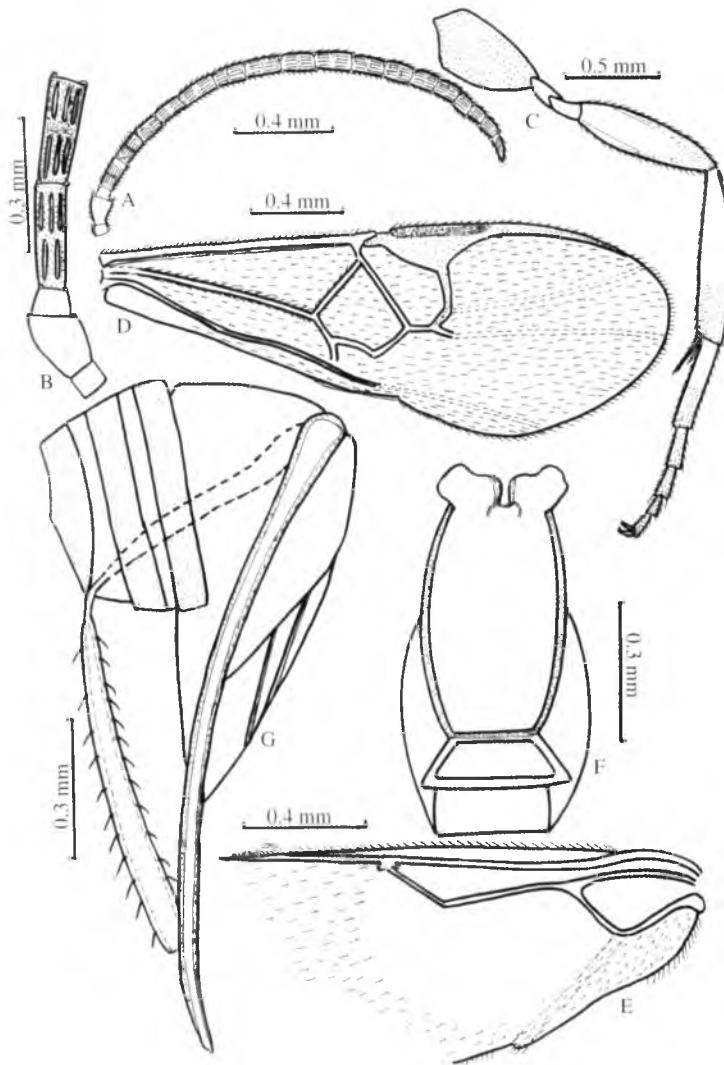
FIGURE 2. A–G.*Apanteles neotaeniaticornis* sp. n. A. Antenna ♀; B. Antenna ♀ enlarged; C.
Hind leg ♀; D. Fore wing ♀; E. Hind wing ♀; F. Metasomal tergites ♀; G. Abdomen with genitalia
♀.

wide as long, finely crenulated and tumescent. The ovipositor sheath (Fig. 2G) about
as long as hind femur.

Cocoon

White, elongated, 2.6 times as long as wide.

Male

Unknown

Holotype: ♀ India: Chhattisgarh, Koriya (Sonhat) (latitude 23.31 °N, longitude 82.16 °E) 26.XII.2007, emerged from the defoliator (undetermined moth) of *Acacia nilotica*, collected by M. Yousuf.

Paratypes: 2♀, data same as for holotype.

Holotype ♀ and 1♀ paratype have been deposited at National Forest Insect Collection, Entomology Division, Forest Research Institute, Dehra Dun, India (Acc. No. 21898).

Discussion

The new species *A. neotaeniaticornis* is quite closely related to *A. taeniaticornis* Wilkinson (Type material based on collection from Java). However the new species differs from the latter in having the following Key characters:

1. Transverse cubital is shorter than the apical portion of the 1st abscissa of the cubital and equal to the pigmented portion of the second abscissa of the cubital; second tergite about 4 times as wide as long; white band present on antennae
   . . . . *A. taeniaticornis* Wilkinson

– Transverse cubital is equal to the apical portion of the 1st abscissa of the cubital and 1.4 times longer than the pigmented portion of the second abscissa of the cubital; second tergite is about 2.3 times as wide as long; white band absent on antennae . . . . *A. neotaeniaticornis* sp. n.

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A key to the Indian species of the genus *Asialeyrodes* Corbett (Hemiptera: Aleyrodidae), with description of two new species

R. Pushpa and R. Sundararaj*

Wood Biodegradation Division, Institute of Wood Science and Technology, 18th Cross Malleswaram, Bangalore 560 003, India
Email: rsundararaj@icfre.org

ABSTRACT: The whitefly genus *Asialeyrodes* of India is reviewed. Two species viz., *A. radiata* sp. nov. on *Salacia oblonga* and *A. tuberculata* sp. nov. on *Symplocos macrocarpa* are described and illustrated. *A. tuberculata* sp. nov. was also noticed to infest *Olea dioica, S. cochinchinensis* subsp. *laurina, Tabernaemontana* sp., and *T. alternifolia*. A key to the Indian species of the genus is given.
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KEYWORDS: Aleyrodidae, *Asialeyrodes*

INTRODUCTION

Corbett (1935) erected the genus *Asialeyrodes* for *A. lumpurensis* and *A. selangorensis* Corbett from Malaya with the former being the type species. Takahashi (1942) added two new species under this genus, viz., *A. euphoriae* and *A. multipori* from Thailand and proposed a new combination *A. maesae* (Takahashi) for *Pseudaleurolobus maesae* from Taiwan. In 1949 he described one more new species *A. corbetti* from Riouw Islands. Ko *et al.* (1993) described *A. lushanensis* as a new species from Taiwan and Martin and Mound (2007) proposed a new combination *A. dorsidemarcata* for *Dialeurodes dorsidemarcata* from Myanmar (Burma). Sundararaj and David (1992) reported this genus for the first time from India with description of *A. indica* as a new species. Regu and David (1992, 1993) and Meganathan and David (1994) described three new species each, bringing the total to seven under this genus from India. Dubey and Sundararaj (2006a) synonymised *A. saklespurensis* Regu and David with *A. indicus* Sundararaj and David, bringing the number of species to six. Martin and Mound (2007) proposed a new combination *A. spherica* (Sundararaj and Dubey) for *Rhachisphora spherica* and proposed a new name and combination *A. dubius*

*Corresponding author

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for *Icfrealeyrodes indica* Dubey and Sundararaj and thus the total number of species known under this genus is 8 in India and 16 in the World. In this paper two species viz., *A. radiata* sp. nov. on *Salacia oblonga* and *A. tuberculata* sp. nov. on *Symplocos macrocarpa* are described and illustrated. A key to the Indian species of the genus is given.

Genus *Asialeyrodes* (Corbett, 1935)

Type species: *Asialeyrodes lumpurensis* (Corbett, 1935). *J. F. M. S. Mus.,* **17**: 841–842; by monotypy.

Icfrealeyrodes Dubey and Sundararaj (2006). *Entomon,* **31** (20): 125–128 (Synonymised by Martin and Mound (2007).

Diagnosis.   Puparia almost flat, broadly elliptical; marginal band narrow; submarginal area wide, separated by a suture-like line around case. Dorsum without conspicuous pores or papillae; thoracic and caudal tracheal folds distinct. Vasiform orifice small, subcordate, not notched, without teeth; operculum subcordate, obscuring lingula. Orifice not surrounded by a trilobed area.

Key to the puparium of Indian species of *Asialeyrodes*

1. Puparium with complete submarginal furrow 2

– Puparium with incomplete submarginal furrow 5

2. Submargin with a row of setae or pro- meso- and metathoracic segments with a pair of setae 3

– Submargin without a row of setae and or pro- meso- and metathoracic segments without a pair of setae 4

3. Puparium dark brown; submargin with a row of setae; pro- meso- and metathoracic segments without a pair of setae . . . .

. . . . *meghalayensis* Regu and David

– Puparium white; submargin without a row of setae; pro- meso- and metathoracic segments with a pair of setae . . . . *radiata* sp. nov.

4. Margin toothed, 8–10 teeth in 0.1 mm; vasiform orifice subcordate, 33.9–37.5 μm long and 40.0–40.1 μm wide; operculum subcordate . . . .

. . . . *splendens* Meganathan and David

– Margin with crenulations, 14–15 crenulations in 0.1 mm; vasiform orifice triangular, 22–23 μm long and 29–30 μm wide; operculum triangular . . . .

. . . . *dubius* Martin and Mound

5. Marginal band present; thoracic tracheal furrows absent 6

– Marginal band absent; thoracic tracheal furrows present 8

6. Submargin without a row of setae; a peripheral row of prominent tubercles absent. 7

– Submargin with a row of setae; a peripheral row of prominent tubercles extending from prothoracic segment to abdominal segment VII present . . . . *elegans* Meganathan and David

7. Cephalic and first abdominal setae capitate, 17.5 μm and 22.5 μm long, respectively . . . . *indicus* Sundararaj and David

– Cephalic and first abdominal setae pointed, 6.17 μm and 9.25 μm long respectively . . . . *menoni* Meganathan and David

8. Puparium without rhachis on cephalothorax and abdomen; submarginal ventral fold absent 9

– Puparium with prominent rhachis on cephalothorax and abdomen; submarginal ventral fold present . . . . *spherica* (Sundararaj and Dubey)

9. Puparium subcircular; I abdominal setae absent; subdorsum without tubercles . . . . *papillatus* Regu and David

– Puparium broadly oval; I abdominal setae present; subdorsum with four pairs of tubercles . . . . *tuberculata* sp. nov.

1. *Asialeyrodes dubius* Martin and Mound

Icfrealeyrodes indica Dubey and Sundararaj (2006b). *Entomon*, **31** (2): 125–128. *Asialeyrodes dubius* Martin and Mound (2007). *Zootaxa*, **1492**: 22–23.

Dubey and Sundararaj (2006b) provided a detailed description of this species.

Material examined

Holotype: puparium of *Icfrealyrodes indica* Dubey and Sundararaj, on *Syzygium* sp., Karnataka: Yana, 17.ii.2001, Coll. A.K. Dubey.

Host

Syzygium sp. (Dubey and Sundararaj, 2006b).

Distribution

India: Karnataka: Yana (Dubey and Sundararaj, 2006b).

2. *Asialeyrodes elegans* Meganathan and David

Asialeyrodes elegans Meganathan and David (1994). *FIPPAT Entomology Series*, **5**: 1–66.

A full description is available in Meganathan and David (1994).

Material examined

Holotype: puparium, on *Sonerilla elegans*, 28.x.1991, Kerala: Walakad, (Silent Valley), 1678 MSL, Coll. P. Meganathan.

Host

Sanerilla elegans (Meganathan and David, 1994).

Distribution

India: Kerala: Walakad, (Silent Valley) (Meganathan and David, 1994).

3. *Asialeyrodes indicus* Sundararaj and David

> *Asialeyrodes indicus* Sundararaj and David (1992). *J. Bombay. Nat. Hist. Soc.*, **88**: 415–424.
> *Asialeyrodes saklespurensis* Regu and David (1993). *Entomon*, **18** (1 and 2): 91–93. (Synonymised by Dubey and Sundararaj (2006a)).

The descriptions provided by Sundararaj and David (1992) and Regu and David (1993) are adequate.

Material examined

Holotype: puparium, *Asialeyrodes saklespurensis* Regu and David, on *Olea* sp., Karnataka, Saklespur, 4.ii.1999, Coll. K. Regu; Holotype: puparium, *Asialeyrodes indicus*, on *Ervatomia coronaria*, Tamil Nadu, Coimbatore, 15.iv.1968, Coll. B.V. David; Kerala: Palode, 1 puparium on *Tabernaemontana alternifolia*, 22.v.07, Coll. R. Pushpa; Karadipara, 11 puparia on *Tabernaemontana gamblei*, 23.x.06, Coll. R. Sundararaj; Pandalam, 7 puparia on *Aporusa* sp, 27.iii.07, Coll. R. Pushpa; Singampara (Palakkad), 9 puparia on *Tabernaemontana alternifolia*, 22.x.06, Coll. R. Sundararaj; Tamil Nadu: Pechiparai, one puparium on *Chionanthus* sp., 22.v.07, Coll. R. Pushpa.

Hosts

Ervatamia coronaria (Sundararaj and David, 1992); *Olea* sp. (Regu and David, 1993); *Antidesma* sp., *Capparis rheedii, Lagerstromea microcarpa, Tabernaemontana heyneana, Schefflera rostrata, Schefflera rostrata, Symplocos* sp., *Smilax zeylanica, Streblus asper, Syzygium* sp., *Xeromphis uliginosa*, (Dubey and Ko, 2008); *Chionanthus* sp. *Olea dioica, Tabernaemontana alternifolia, T. gamblei*, (new host records).

Distribution

India: Maharashtra: Mumbai (Sundararaj and David, 1992); Karnataka, Saklespur (Regu and David, 1993); Goa: Kulem; Karnataka: Kudremukh National Park, Kumargiri. Puspagiri Wildlife Sanctuary, Yellapur, Saklespur, Jog falls, Gokarna, Unachali falls, Idegundi, Allawar, Mangalore; Kerala: Calicut, Singampara (Palakkad), Palode; Tamil Nadu: Pechiparai, (new distribution records).

4. *Asialeyrodes meghalayensis* Regu and David

Asialeyrodes meghalayensis (Regu and David, 1992). *J. Bombay Nat. Hist. Soc.*, **88**: 256–258.

A full description is available in Regu and David (1992).

Material examined

Holotype: puparium on *Ixora brachiata*, 21.x.1989, Meghalaya: Cherrapunjee. Coll. B. V. David.

Host

Ixora brachiata (Regu and David, 1992).

Distribution

India: Meghalaya: Cherrapunjee (Regu and David, 1992).

5. *Asialeyrodes menoni* Meganathan and David

Asialeyrodes menoni Meganathan and David (1994). *FIPPAT Entomology Series*, **5**: 1–66.

The description of this species by Meganathan and David (1994) is adequate.

Material examined

Holotype: puparium on *Litsea laevigata*, 2.ii.1991, Kerala: Nilikkal (Silent Valley), 1150 MSL. Coll. P. Meganathan.

Host

Litsea laevigata (Meganathan and David, 1994).

Distribution

India: Kerala: Nilikkal (Silent Valley) (Meganathan and David, 1994).

6. *Asialeyrodes papillatus* Regu and David

Asialeyrodes papillatus Regu and David (1992). *J. Bombay Nat. Hist. Soc.*, **88**: 256–258.

A full description is available in Regu and David (1992).

Material examined

Holotype: puparium on *Ixora brachiata*, 21.x.1989, Meghalaya: Cherrapunjee. Coll. B. V. David.
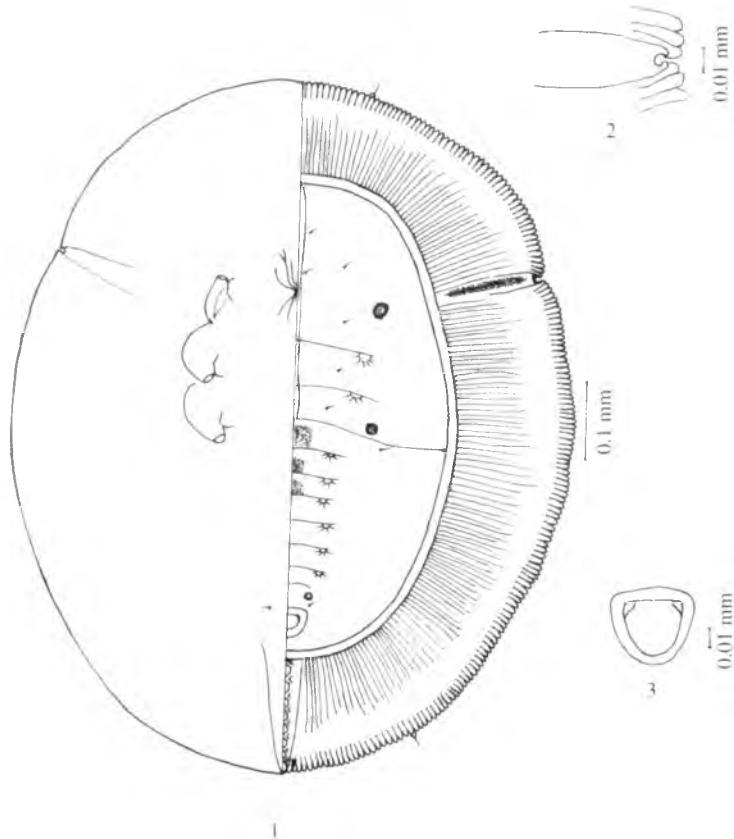
FIGURES 1–3. *Asialeyrodes radiata* Pushpa and Sundararaj sp. nov. : 1. Puparium; 2. margin
with thoracic tracheal fold; 3. vasiform orifice.

Host

Ixora brachiata (Regu and David, 1992).

Distribution

India: Meghalaya: Cherrapunjee (Regu and David, 1992).

7. *Asialeyrodes radiata* sp. nov. (Figs. 1–3)

Puparium: White, without wax secretion; subcircular, 1.14–1.15 mm long, 0.94–0.96
mm wide; broadest at metathoracic segment region and slightly constricted at thoracic
tracheal pore region; found singly on the lower surface of leaves. Margin toothed, 14–
16 teeth in 0.1 mm; thoracic and caudal tracheal pores distinct; anterior marginal setae
10–14 μm and posterior marginal setae 12–16 μm long.

Dorsum: Submargin demarcated completely by broad submarginal furrow around the case from the dorsal disc, 182 μm wide, with distinct striations radiating from the periphery of the submarginal furrow which runs towards the margin. Three pairs of tubercles — abdomen with a pair submedially on VIII abdominal segment, cephalothorax with two pairs, one pair each laterad of pro- and metathoracic segments. Dorsum smooth, after staining an orange coloured patch mesad of I, II and III abdominal segments, lateral depressions present in all segments. Three rows of pores and porettes, one row each on the inner periphery of the submarginal furrow, on submedian area and on subdorsal area and an uneven row of pore and porettes on submargin distinct. Longitudinal and transverse moulting sutures reaching submarginal furrow.

Chaetotaxy: Cephalic setae 8–10 μm long, first abdominal setae 4 μm long, eighth abdominal setae cephalolaterad of vasiform orifice 8 μm long and a pair of submarginal caudal setae 4 μm long. Cephalothorax with five pairs of setae- one pair each on pro-, meso- and metathoracic segments and two pairs on cephalad, in the periphery of the longitudinal moulting suture.

Vasiform orifice: Subcordate, wider than long 34–40 μm long, 42–44 μm wide; operculum similarly shaped, 26–30 μm long, 28–34 μm wide, filling the orifice, obscuring lingula. Thoracic and caudal tracheal furrows distinct with polygonal markings.

Venter: A pair of ventral abdominal setae 8 μm long, 62 μm apart; thoracic and caudal tracheal folds indicated without stipples. Antennae reaching base of prothoracic legs.

Material examined

Holotype: puparium, Kerala: Thrissur, on *Salacia oblonga*, 24.x.06, Coll. R. Sundararaj, deposited in the collection of National Forest Insect Collection, Forest Entomology Division, Forest Research Institute, Dehra Dun, India (NFIC # 21853). Paratypes, 2 puparia, data as for holotype, one each deposited in the collection of Division of Entomology, Indian Agricultural Research Institute, New Delhi, India and Zoological Survey of India, Kolkata, India (2428/H15).

Etymology

Named to reflect its radial striations from submarginal furrow.

Comments

This species resembles *A. splendens* Meganathan and David in having complete submarginal furrow, submedian tubercles on pro- and metathorax and furrows with polygonal markings but differs in having submarginal striations radiating from submarginal furrow, submedian tubercle on VIII abdominal segment, submedian setae on pro-, meso- and metathorax and two pairs on cephalad and by the absence of a peripheral row of submedian papillae.

8. *Asialeyrodes spherica* (Sundararaj and Dubey)

> *Rhachisphora spherica* Sundararaj and Dubey (2006). *J. Bombay. Nat. Hist. Soc.*, **103** (1): 69.
> *Asialeyrodes spherica* (Sundararaj and Dubey) Martin and Mound (2007). *Zootaxa*, **1492**: 23.

Sundararaj and Dubey (2006) provided a detailed description of this species.

Material examined

Holotype: puparium of *Rhachisphora spherica* Sundararaj and Dubey, on *Caesalpinia pulcherimma*, 22.i.2001, Karnataka: Bangalore, Coll. A.K. Dubey.

Host

Caesalpinia pulcherimma (Sundararaj and Dubey, 2006).

Distribution

India: Karnataka: Bangalore (Sundararaj and Dubey, 2006).

9. *Asialeyrodes splendens* Meganathan and David

> *Asialeyrodes splendens* Meganathan and David (1994). *FIPPAT Entomology Series*, **5**: 1–66.

The description of this species by Meganathan and David (1994) is adequate.

Material examined

Holotype: puparium, on *Microtropis ramiflora*, 29.x.1991, Kerala: Sispara (Silent Valley), 2206 MSL, P. Meganathan.

Host

Microtropis ramiflora (Meganathan and David, 1994).

Distribution

India: Kerala: Sispara, (Silent Valley) (Meganathan and David, 1994).

10. *Asialeyrodes tuberculata* sp. nov. (Figs. 4–6)

Puparium: White, flat without wax secretion; broadly oval, 0.88–1.14 mm long, 0.72–0.98 mm wide; broadest at metathoracic segment region and slightly constricted at thoracic and caudal tracheal pore regions; found in groups on the lower surface of leaves. Margin smooth with no marginal band; thoracic and caudal tracheal pores distinct with chitinised rim; anterior marginal setae 20 μm and posterior marginal setae 24 μm long.
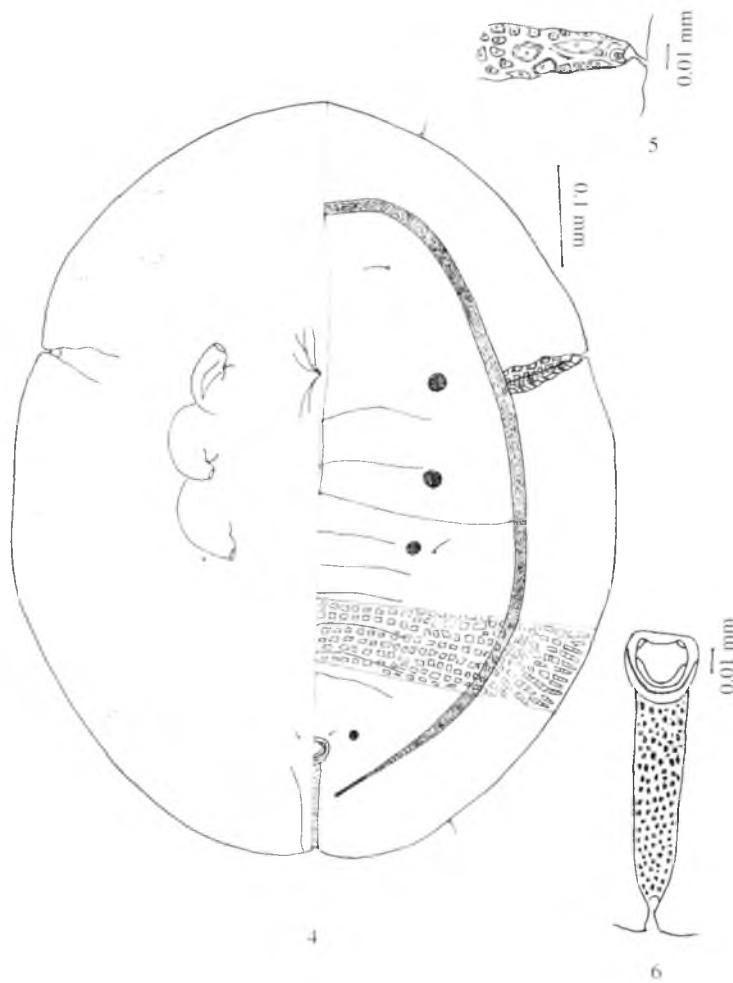
FIGURES 4–6. *Asialeyrodes tuberculata* Pushpa and Sundararaj sp. nov. : 4. Puparium; 5. margin with thoracic tracheal furrow; 6. vasiform orifice

Dorsum: Dorsum with polygonal structures, submargin demarcated from the dorsal disc by broad incomplete submarginal furrow, 120–166 μm wide, submarginal striations absent. Four pairs of subdorsal tubercles — one pair each on pro-, meta-, II abdominal segment and on cephalolaterad of vasiform orifice. Pores and porettes distributed throughout dorsum. Longitudinal and transverse moulting sutures reaching submarginal furrow.

Chaetotaxy: cephalic setae 10–14 μm long, first abdominal setae 8–12μm long, eighth abdominal setae cephalolaterad of vasiform orifice 8–10 μm long and submarginal caudal setae 8–10 μm long.

Vasiform orifice: Small, subcordate, wider than long 32–34 μm long, 36–42 μm wide; operculum similarly shaped, 22–2 μm long, 32–34 μm wide, filling the orifice, obscuring lingula. Thoracic and caudal tracheal furrows distinct with polygonal markings.

Venter: A pair of ventral abdominal setae 1014 μm long, 36–38 μm apart; thoracic and caudal tracheal folds faintly discernible. Antennae reaching base of prothoracic legs.

Material examined

Holotype: puparium, India: Kerala: Munnar, on *Symplocos macrocarpa*, 28.iii.07, Coll. R. Pushpa, deposited in the collection of National Forest Insect Collection, Forest Entomology Division, Forest Research Institute, Dehra Dun, India (NFIC # 21854). Paratypes, 9 puparia, data as for holotype; Palakkad, 2 puparia on *Symplocos cochinchinensis* subsp. *laurina*, 23.x.06, Coll. R.Sundararaj; Karnataka: Nagarahole Rajiv Gandhi National Park, 6 puparia on *Olea dioica*, 14.iii.06, Coll. R. Pushpa; Shrinkeri, 10 puparia on *Tabernaemontana* sp. 14.vi.07, Coll. R. Pushpa; Shrinkeri, 9 puparia on *Tabernaemontana alternifolia*, 14.vi.07, Coll. R. Pushpa, one each deposited in the collection of Division of Entomology, Indian Agricultural Research Institute, New Delhi, India and Zoological Survey of India, Kolkata, India (2429/H15) and the remaining in the collection of Institute of Wood Science & Technology, Bangalore, India.

Etymology

Named to reflect its four pairs of subdorsal tubercles.

Comments

This species resembles *A. menoni* Meganathan and David in having incomplete submarginal furrow, pointed dorsal setae, dorsum and caudal tracheal furrow with polygonal markings but differs in having four pairs of subdorsal tubercles, distinct thoracic tracheal furrows with polygonal markings and by the absence of marginal band.

Discussion

Asialeyrodes is a small genus currently includes 18 species with the two species described here. It is so far reported mainly from Oriental region and two species from Eastern Palearctic region. Among the 18 species so far known in the world 10 species are known from India.

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Boil-off loss in cocoons and filament neatness of selected breeds of silkworm, *Bombyx mori* Linn. reared in different seasons

A. Naseema Begum*, S. M. Moorthy and S. Nirmal Kumar

Central Sericultural Research and Training Institute, Mysore 570 008, India
Email: naseemcsrti@yahoo.com

ABSTRACT: The boil-off loss percentage and filament neatness in the cocoons of 24
bivoltine silkworm breeds comprising 12 Chinese type oval breeds and 12 Japanese
type dumbbell breeds were assessed in the laboratory. JPN8 among the oval breeds
and EHT among the dumbbell breeds were identified for low boil-off loss and CSR3
among the oval breeds and 5HT among the dumbbell breeds showed higher filament
neatness. The above breeds were identified as potential resource material for future
breeding programmes. © 2010 Association for Advancement of Entomology

In silkworm breeding boil-off loss with reference to cocoon shell has been given
great importance in addition to other qualitative and quantitative traits (Harada *et al.*,
1961; Yokoyama, 1979). Similarly filament neatness in polyvoltine *x* bivoltine hybrids
is known to be of low quality when compared with the bivoltine *x* bivoltine hybrids
(Sonwalkar, 1961; Naseema Begum *et al.*, 2004). Thus, boil-off loss and filament
neatness are considered as important parameters in selecting silkworm breeds. Hence
in the present study 24 bivoltine breeds were screened in the laboratory on these
criteria.

Twelve Chinese type oval breeds (A1, A3, A 104, AHT, BHT, A70, CSR2, CSR3,
CSR18, 8HT, JPN8, KA (control)) and 12 Japanese type dumbbell breeds (916B,
935E, EHT, FHT, GHT, B60, B63, CSR6, CSR16, CSR19, 5HT, NB4D2 (control))
were screened in the laboratory. All the breeds were reared in five replications during
summer (28–30 °C & 60–70% RH), rainy (26–28 °C & 80%–90% RH) and winter
(24–26 °C & 50%–70% RH) seasons for three years. Standard rearing techniques
(Krishnaswami, 1988) were followed.

For each breed, ten female and male cocoon shells were selected from each of the
five replications for estimating boil-off loss. The boil-off loss was estimated by the
method suggested by Basavaraja *et al.* (2000). A total of 300 cocoons of each breed

*Corresponding author

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TABLE 1. Boil-off loss and filament neatness in different breeds of silkworm observed in different seasons

Breed	Rainy		Summer		Winter	
	Boil-off loss (%)	Neatness (p)	Boil-off loss (%)	Neatness (p)	Boil-off loss (%)	Neatness (p)
Oval breeds						
A1	24.28	92.2	24.91	91.7	24.64	93.0
A3	24.06	92.2	25.02	91.8	26.35	93.0
CSR2	25.10	92.2	25.47	92.0	25.3	93.0
CSR3	24.66	92.7	25.18	92.0	25.72	93.0
CSR18	23.97	92.2	24.89	92.0	24.11	92.0
JPN8	21.39	92.2	22.58	91.8	23.92	93.0
A70	25.41	92.2	25.64	91.7	27.49	93.0
8HT	23.80	92.2	25.09	91.2	25.81	93.0
AHT	23.21	92.2	24.41	91.7	24.31	92.0
A104	24.70	92.2	25.55	91.6	27.47	93.0
BHT	23.84	92.2	24.71	91.6	25.77	92.0
KA (Control)	24.41	92.3	25.87	91.0	26.84	92.0
CD at 5%	1.43	0.3	0.46	0.4	0.90	NS
Dumbbell breeds						
935E	24.71	92.3	24.65	92.0	25.51	92.0
FHT	25.33	92.2	26.88	91.0	24.70	92.0
CSR6	24.43	92.2	27.38	92.0	27.20	92.0
CSR16	23.33	92.2	25.28	92.0	25.26	92.0
CSR19	25.06	92.2	26.98	92.0	25.04	91.0
B60	25.76	92.7	26.65	92.0	26.23	92.0
5HT	25.00	92.7	26.55	92.0	26.61	92.0
B63	24.63	92.2	26.24	92.0	25.41	92.0
EHT	23.47	92.2	25.12	91.0	24.01	92.0
GHT	24.59	92.2	25.13	92.0	25.40	92.0
916B	24.14	92.7	24.55	92.0	25.73	92.0
NB4D2 (control)	26.14	91.7	26.26	91.0	26.22	92.0
CD at 5%	1.00	0.5	0.17	NS	1.04	NS

from five replications were reeled in a multi-end reeling machine and the silk was loaded in 10 panels and neatness points were scored with the standard values. The data were statistically analysed.

The data are presented in Table 1. Among the Chinese type oval breeds, JPN8 showed lowest boil-off loss (21.39 %) followed by AHT (23.21%) and 8HT (23.80%) during rainy season. In summer also the breed JPN8 showed lower values (22.58%) followed by AHT (24.41%) and BHT (24.71%); during winter the breed JPN8 showed

lower values (23.92%) along with CSR18 (24.11%) followed by AHT (24.31%) and A1 (24.64%).

In case of Japanese type dumbbell breeds, CSR16 (23.3%) showed lowest value for boil-off loss followed by EHT (23.5%) and 916B (24.1%) in rainy season. During summer, out of the 12 breeds, three breeds *viz.*, 916B (24.55%), 935E (24.7%) and EHT (25.12%) showed lower values for boil off loss. However, during winter the breed EHT (24.0) showed the lowest value followed by FHT (24.7%) and CSR19 (25.0%), respectively.

Generally bivoltine breeds have low boil off loss than the multivoltine breeds due to less floss (Sidhu and Sonwalker, 1969). Basavaraja *et al.* (2000) reported that the boil-off loss in bivoltine breeds is about 24%. The boil-off loss also showed significant variation between oval and dumbbell breeds and is in concurrence with the observations of Basavaraja *et al.* (2000) that the boil-off loss percentage is genetically different among different silkworm breeds.

Significant differences ($p < 0.05$) were observed among the Chinese type oval breeds with reference to filament neatness during rainy and summer seasons and while data during winter season did not vary significantly. Similarly among the Japanese type dumbbell breeds significant variations occurred during rainy season alone. In oval breeds, the neatness (p) varied from 91.77 to 92.57 p, whereas in dumbbell, it ranged from 91.57 to 92.23 p. Analysis of the trait, neatness among oval breeds in different seasons showed higher values in the breed CSR3 (92.7p) followed by KA (92.3p) during rainy season. During summer season, higher neatness in three breeds namely CSR2, CSR3 and CSR18 and during winter no remarkable differences among the other breeds were observed.

Among the Japanese type dumbbell breeds, higher neatness was observed in B60, 5HT and 916B (92.7p) during rainy season. However, during winter and summer no remarkable differences were observed among the breeds.

The silk yarn with higher filament neatness is used as warp for making fabric. Sonwalker (1991) established that higher neatness results in less defects and the silk may be used in warp during weaving of silk yarn.

Based on the above observations JPN8 among the oval breeds and EHT among the dumbbell breeds (for low boil-off loss) and CSR3 among the oval breeds and 5HT among the dumbbell breeds (for filament neatness) were identified as potential resource material for future breeding programmes.

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Fat body protein profile of life stages of *Rhynocoris marginatus* (Fabricius) (Heteroptera: Reduviidae)

Arul Baskar[1], M. C. John Milton[1] and Dunston P. Ambrose*[2]

[1]*Department of Advanced Zoology and Biotechnology, Loyola College (Autonomous), Chennai 34, Tamil Nadu, India*
[2]*Entomology Research Unit, St. Xavier's College (Autonomous), Palayankottai 627 002, Tamil Nadu, India*
Email: eruxavier@gmail.com

ABSTRACT: The reduviid predator, *Rhynocoris marginatus* (Fabricius) is an important biocontrol agent against several field crop pests in India. The present study was conducted to understand the protein profile of fat body in different life stages of *R. marginatus*. Comparison of electropherograms of nymphal instars and adults revealed that the number of protein bands increased from nymphal instars to adults and from young adults to old ones. The protein content was greater in female.
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The insect fat body participates in multiple biochemical and physiological functions and also serves as a major site for synthesis and storage of lipids, proteins, carbohydrates and nitrogenous components (Keeley, 1985). Fat body functions specific to a particular developmental stage are hormonally regulated and lead to distinct gene expression patterns that accommodate the needs of each developmental stage (Haunerland and Shirk, 1995; Raikhel et al., 1997; Miller et al., 2002). Though the production of stage specific proteins in the fat body cells was documented in the holometabolous insects the hemimetabolous insects where stage specificity is less distinct have received less attention so far. Hence, in the present study the qualitative changes of protein in the fat body of a harpactorine assassin bug *Rhynocoris marginatus* were analyzed. Such an understanding will help in the formulation of a synthetic feed or to choose suitable prey species to mass rear this predator for Integrated Pest Management Programmes (Ambrose, 2010).

Adults and nymphal instars of *R. marginatus* were reared in the laboratory on rice moth larvae *Corcyra cephalonica* Stainton following standard procedures. Newly moulted nymphal instars and freshly emerged adults were used in the experiments.

*Corresponding author

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TABLE 1. Electrophoretic characteristics of fat body protein of life stages of
Rhynocoris marginatus.

Life stage	Number of bands	Molecular weight (kDA)		Rm value	
		I Fold	II Fold	I Fold	II Fold
I nymphal instar	3	80.1	57.5	0.35	0.45
II nymphal instar	5	**80.1**	57.5	0.34	0.45
III nymphal instar	5	**80.1**	57.5	0.35	0.46
IV nymphal instar	6	**80.1**	57.5	0.34	0.45
V nymphal instar	7	80.1	57.5	0.34	0.45
0 day adult	9	87.1	77.6	0.23	0.34
2 day adult	9	**87.1**	77.6	0.25	0.33
4 day adult	10	**87.1**	77.6	0.24	0.33
6 day adult	13	**87.1**	77.6	0.25	0.33
8 day adult	14	**87.1**	77.6	0.25	0.32
Male	12	89.1	81.3	0.24	0.32
Female	14	89.1	81.3	0.23	0.31

Fat bodies of zero day old I, II, III, IV and V nymphal instars and 0, 2, 4, 6, and 8 day old adults were dissected out and washed in insect ringer solution (7.5 g NaCl, 0.35 g KCl, 0.28 g anhydrous $CaCl_2$/1). About 30 mg of the sample was homogenized in 100 μl of sample buffer (pH 7.2) and centrifuged at 15,000 rpm for 10 min at 4 °C. The supernatant was stored at -4 °C. When needed it was heated for two min in a water bath and centrifuged.

Protein concentration of fat body was determined according to the method of Lowry *et al.* (1951). Bovine serum albumin was used as the standard. To analyse the fat body protein profile two dimensional SDS-PAGE (Laemmli, 1970) was carried out. The molecular weights of protein fractions were calculated by determining their relative mobility (R_m).

The fat body protein profiles of different age groups of *R. marginatus* are shown in Table 1. The fat body proteins of nymphal instars showed almost similar molecular weights and R_m values but the number of bands increased from 3 to 7. The number of bands also increased from 9 to 14 in newly emerged adults to 8 d old adults. In male and female insects the numbers of bands were 12 and 14, respectively. Significant variations are lacking in Rm values and molecular weights of protein present in different growth stages of *R. marginatus.*

Thus, the protein profile of fat body of *R. marginatus* adults differed from not only that of nymphal instars but also among different adult age groups. New proteins appeared in the adults that were absent in the nymphal instars suggesting that fat body is the centre of protein synthesis from where it is transported into the haemolymph (Telfer and Kunkel, 1991, Kunkel and Nordin, 1985; Rohrkasten and Ferenz, 1985).

The difference in the number of bands between male and female *R. marginatus* could be attributed to the presence of female protein like vitellogenin as reported in several insects belonging to diverse groups (Brooks, 1969; Engelmann, 1969; Pan *et*

al., 1969; Hagedorn and Judson, 1972; Ziegler *et al.*, 1995; Wiesner *et al.*, 1997). Thus, the fat body protein profile underwent significant qualitywise as well as quantitywise changes among the the life stages of *R. marginatus* as reported by Telfer and Kunkel (1991). This suggests that selection of prey species or manufacture of synthetic diet that could give developmental stagewise or sexwise specific proteins is imperative for the mass rearing of *R. marginatus* (Ambrose, 2010). Detailed further studies on these lines will reveal hitherto unknown nutritional requirements of this species.

ACKNOWLEDGEMENTS

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Appraisal of quality parameters of *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) as affected by prolonged cold storage of parasitoid cards

N. Geetha

Division of Crop Protection, Sugarcane Breeding Institute, Coimbatore 641 007, Tamil Nadu, India
Email: mvsbi@yahoo.com

ABSTRACT: *Trichogramma chilonis* Ishii is routinely used against moth borers in sugarcane as inundative releases. The parasitoid is mass produced and stored regularly under low temperature before packaging for release. In this study the effect of such storage on the quality parameters of the parasitoid and its progeny production were assessed. The *T. chilonis* pupae were stored as "Trichocards" for 20, 40, 60, 75 and 90 days in refrigerated conditions at 10 ± 1 °C and $50 \pm 5\%$ RH, in complete darkness. The *T. chilonis* pupae tolerated cold temperature. The percent of emerged adults, deformed adults, sex ratio, fecundity and mobility of the parasitoid were affected severely after 3 weeks of cold storage. Impact of cold storage on the performance of the parasitoid is discussed in relation to the field dose needed for management of pests. © 2010 Association for Advancement of Entomology

KEYWORDS: *Trichogramma chilonis*, cold storage, quality parameters

Among trichogrammatids, *Trichogramma chilonis* is the most commercialized species used in India and promoted in sugarcane crop for inundative releases against moth borers. The success of these releases depends not only on number of parasitoids per release, frequency of release and delivery of the parasitoids within the field but mainly on their quality. The parasitoid is produced in mass scale and usually stored in refrigerated conditions before it is marketed and further transported for distribution to the farmers. Very often the commercial units produce surplus stock and store the same as "Trichocards" in refrigerators till the demand for supply arises. This is also done to compensate the lower production of *T. chilonis* during summer months. Good storage technique must ensure not only the availability of natural enemies but also their quality.

Though several studies have been carried out on the effect of cold storage on trichogrammatids (Jalali and Singh, 1992; Khosa and Brar, 2000; Kumar *et al.*, 2005) they have not yet covered all aspects of quality parameters. Often, even if the

parasitoids emerged from stored Trichocards, they may be weak or deformed and their fecundity may be affected. Therefore this study was taken up to assess the response of *T. chilonis* to refrigerated conditions in the generation that is stored as well as in the F1 progeny, covering all the quality parameters relevant to their field performance.

T. chilonis used in this study is a laboratory population, reared on *Corcyra cephalonica* eggs. A sample consisted of a small piece of freshly parasitized trichocard having approximately 100 eggs placed in a glass tube. The pupal stage was tested as it is the stage at which the commercial production units store the parasitoids and in many Trichogrammatids it is the stage which tolerates cold storage (Jalali and Singh, 1992). The trichocards at pupal stage were stored at $10 \pm 1\,^\circ$ C in a refrigerator, $50 \pm 5\%$ RH and stored for 20, 40, 60, 75 and 90 days to be compared with the fresh trichocards prepared in laboratory. All the cards were removed from refrigerator and shifted to the ambient temperature in the laboratory ($28 \pm 2\,^\circ$C (day) and $20 \pm 2\,^\circ$C (night), once the test period was completed, to observe the quality parameters.

The quality of the parasitoids was evaluated through assessment of percentage of adult emergence, deformed adults, active adults and females as well as fecundity. All the observations were taken on 15 samples for each treatment period. An additional set of 15 samples was used for assessing the mobility.

For the percent parasitism 10 pairs of freshly mated adults (assumed sex ratio of 1:1) from the samples were allowed to parasitize ca. 100 eggs of UV-sterilized *C. cephalonica* eggs for 24 h. A separate set of 15 samples was maintained at the specified storage periods to obtain F1 progeny. The comparison among the treatments was done using Duncan's Multiple Range Test (DMRT).

The data and results of statistical analysis are presented in Table 1. In samples stored for 75 days very few adults emerged and after 90 days of storage no adults emerged. Hence comparisons were made among the trichocards stored for periods of 0, 20, 40 and 60 days. The percent of adult emergence in the parental generation decreased (89.35% to 33.06%) significantly while the percent deformed adults increased (3.2% to 21.85%) significantly with increasing storage time in the refrigerator. Cold storage up to 20 days did not affect per cent females or percent parasitization and the percent mobile adults did not vary among the trichocards stored up to 40 days. Varying degree of losses in fecundity of *T. chilonis* due to storage had been reported earlier (Jalali and Singh, 1992; Khosa and Brar, 2000; Kumar *et al.*, 2005; Singh *et al.*, 2001).

The cumulative effect of storage on the quality was assessed by deriving the percentage of potentially useful parasitoids, AE (Tezze and Botto, 2004) using the formula $AE = \{[E - (E * D)] * M\} * 100$ where AE is added effect of storage; E is per cent adult emergence/100; D is per cent deformed adults/100; and M is per cent active adults/100. The resulting AE is the percentage of potentially useful parasitoids. It was highest (70.34) when the pupae were not stored and the least (9.64) when stored for 60 days. A similar trend was seen in F1 generation (Table 1).

Though the effect of storage on all quality parameters were continued to F1 progeny, the degree of impact was low. The percentage of deformed adults did not vary in the F1 progeny from trichocards stored up to 40 days. The percent females was

TABLE 1. Quality parameters of *T.chilonis* stored in refrigerator for varying periods

Storage period (days)	Percent adult emergence	Percent deformed adults	Percent active adults	Percent females	Percent parasitism	AE
			Parental generation			
0	89.35[a]	3.20[a]	81.33[a]	69.20[a]	92.67[a]	70.34
20	82.61[b]	5.63[b]	80.42[a]	68.70[a]	84.21[a]	62.69
40	70.41[c]	8.60[c]	72.75[b]	54.30[b]	72.30[b]	46.73
60	33.06[d]	21.85[d]	37.34[c]	41.34[c]	61.08[c]	9.64
			F1 generation			
0	91.21[a]	3.14[a]	87.60[a]	72.10[a]	94.21[a]	77.39
20	81.84[b]	4.31[a]	76.13[b]	64.21[b]	86.74[b]	59.60
40	72.36[c]	4.36[a]	63.71[c]	61.32[b]	80.67[c]	44.09
60	68.41[c]	7.81[b]	52.64[d]	52.82[c]	74.24[d]	33.31

Means showing similar letters are not significantly different ($P = 0.05$).
AE, added effect of storage.

72.1 in the F1 progeny derived from cards which were not stored and no difference between the storage periods of 20 and 40 days was observed. A high level of parasitoid emergence is essential as emergence levels in the field are generally lower than that in the laboratory (Bigler *et al.*, 1993). Decline in adult emergence in this species due to cold storage has been recorded by many workers (Jalali and Singh, 1992; Naiding *et al.*, 2007). Locomotion has been shown to be a good predictor of field efficacy (Voegele, 1988) and thus the reduction in percent mobile adults due to storage should be taken into account during quality tests by a commercial unit.

The general vigour of *T. chilonis* is measured through its longevity and fecundity (Stinner, 1977) which were affected due to storage. The drop in numbers of females in the present study due to cold storage could be a matter of concern since the first step in a successful programme is to ensure that a specific number of non-deformed female parasitoids are released per unit area. The potentially useful parasitoids were less than 50 per cent at 40 days of storage in either of the generations. In both the parental generation and F1 generation in the control group itself the rate of potentially useful adults differed approximately by 10 per cent showing natural variation from batch to batch.

All these factors would have to be taken into account when deciding on permissible storage period and a release dose for inundative releases of the parasitoid. Fine-tuning for the loss of quality at each stage of the parasitoid development and storage for different periods would result in release of required quantities of parasitoid for effective pest management.

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Occurrence of Japanese black rice bug, *Scotinophora lurida* (Blumeister) (Hemiptera: Pentatomidae) in light trap catches in rice ecosystem at Aduthurai, Tamil Nadu, India

S. Mohammed Jalaluddin, G. Ravi, K. Chozhan, T. Umadevi and S. Jebaraj

Agricultural Entomology Unit, Tamil Nadu Rice Research Institute, Tamil Nadu Agricultural University, Aduthurai 612 101, India
Email: jalalzas@yahoo.com

ABSTRACT: The occurrence of black rice bug in different periods was monitored through light trap. Japanese black rice bug *Scotinophara lurida* (Blumeister) was the only species intercepted in the light trap at the institute central farm. Four fluctuating peak catches of black bug were recorded during August 2008, and February, March and April 2009. There was no significant correlation between light trap catches and abiotic factors during the period under study.
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KEYWORDS: Japanese black rice bug, *Scotinophora lurida*, light trap

Black bugs of the genus *Scotinophora* are common pests of rice in Indonesia, Malaysia, Japan and throughout Asia (Miyamota *et al.*, 1983). Of the six *Scotinophora* spp. present on rice in the Philippines, the black paddy bug, *Scotinophora coarctata* (F) alone was reported as a serious pest (Barrion *et al.*, 1982). In Tamil Nadu, sporadic but severe outbreak of the pest was reported (Uthamasamy and Mariappan, 1985; Subramanian *et al.*, 1986; Saroja *et al.*, 1993; Anandhi *et al.*, 2008). Rice black bug has become a menace during the past seven years.

The movement of adult insects in the rice ecosystem at Tamil Nadu Rice Research Institute, Aduthurai was monitored by the use of light trap with 125 W mercury vapour lamp from March 2008 to April 2009. The corresponding meteorological data were also collected and compiled. Daily catches between 6 PM to 6 AM were recorded. Adults of *Scotinophara* spp. were sorted out and identified according to taxonomic characters described by Barrion and Listinger (1994).

Scotinophora lurida appeared in the light trap in large numbers during August 2008, and February to April 2009, total catches in the months being 1326, 3395, 2380 and 7077, respectively (Table 1), with a peak single day catch of 28,057 bugs on 12

TABLE I. Catches of *Scotinophora lurida* in light traps
during 2008–2009 at Aduthurai, Tamil Nadu

Month & Year	Total No. of S. *lurida* trapped	% of S. *lurida* in total light trap catch
March'08	1438	5.99
April	163	0.27
May	–	–
June	15	0.10
July	–	–
August	1326	5.65
September	93	0.47
October	46	0.16
November	–	–
December	–	–
January'09	330	0.57
February	3395	3.98
March	2380	3.06
April	7077	13.54
May	–	–

March 2009. Ferer and Shepard (1987) and Anandhi *et al.* (2008) studied the light trap catches of black bug and recorded high incidence in mid-August, mid-April and June. Significant correlation of light trap catches and abiotic factors were lacking in the data collected. Further observations are needed on taxonomic characters, species shift/dominance over crop stages, season, light trap catches, and correlation with abiotic factors and cropping pattern.

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In the checklist he has indicated that this species infests *Sauropus androgynus* in Kerala. In addition, he has listed the following euphorbiaceous plants as its host in India: *Acalypha godseffiana, A. hispida, A. indica, A. wilkesiana, Aleurites trisperma, Bridelia retusa, Breynea patens, Codiaceum variegatum, Croton sparsiflorus, Euphorbia fulgens, E. geniculata, E. pulcherrima, Excoecarina agallocha, Jatropha podagrica, Macaranga peltata, Mallotus philippinensis, Manihot esculentus, M. gloziovii* and *Ricinus communis*. In Coimbatore the whitefly has been noticed to infest Chekurmanis for the first time during March 2008.

The whitefly, *Bemisia euphorbiae* (David and Subramaniam) was noticed to infest Chekurmanis severely during March to August 2009 and it is the first record of its occurrence on this plant. This species was described by David and Subramaniam (1976) as *Lipaleydes euphorbiae* from *Euphorbia hirta* and *Phyllanthus amarus* and by David and Thenmozhi (1995) from *Phyllanthus acidus* and *P. maderaspatensis*. Dubey *et al.* (2009) synonymised *Lipaleyrodes* with *Bemisia* forming a new combination *Bemisia euphorbiae* (David and Subramaniam). *Sauropus androgynus* is a new host record for this species of whitefly.

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Two whitefly pests of Chekurmanis, *Sauropus androgynus* Merr. in Coimbatore, Tamil Nadu, India

Philomena George[1] and B. Vasantharaj David[2]

[1]*Biotechnology Department, Karunya University, Coimbatore 641 114, India*
Email: drphil2006@gmail.com
[2]*Sun Agro Biotech Research Centre, Madanandapuram, Porur, Chennai 600 116, India*
Email: sabrcchennai@yahoo.co.in

ABSTRACT: Two whiteflies, the spiraling whitefly, *Aleurodicus dispersus* and *Bemisia euphorbiae* are reported to infest heavily Chekurmanis, *Sauropus androgynus* in Coimbatore during 2008 and 2009, making the leaves unfit for consumption. The spiraling whitefly occurrence on this plant in Coimbatore is new whereas it has been reported on Chekurmanis in Kerala. The occurrence of *B. euphorbiae* is a new record on this host plant in India. © 2010 Association for Advancement of Entomology

KEYWORDS: *Aleurodicus dispersus, Bemisia euphorbiae, Sauropus androgynus,* Chekurmanis, spiraling whitefly

Chekurmanis, *Sauropus androgynus* Merr. (Euphorbiaceae), a perennial shrub, is a green leafy vegetable introduced from Malaysia, the leaves of which are eaten raw or cooked. Sivagami *et al.* (1965) observed the occurrence of the chillies thrips, *Scirtothrips dorsalis* Hood., the brown scale, *Saissetia hemisphaerica* Targ. (= *S. coffeae*) and the aphid, *Aphis malvae* Koch. on this plant in Coimbatore during 1963. Thrips was noted to be the serious pest as the production of leaves, the main source of vegetable, is adversely affected. David and Ananthakrishnan (2004) have listed the insects affecting Chekurmanis in India.

During March to August 2008 and 2009 heavy incidence of two whiteflies was noticed on *S. androgynus* in Coimbatore. The tender leaves were heavily infested making the leaves unfit for consumption. The whiteflies have been determined as *Aleurodicus dispersus* Russell and *Bemisia euphorbiae* (David and Subramaniam). Both the species occurred together on the undersurface of leaves covering almost entire leaf area and *A. dispersus* was predominant.

The spiraling whitefly, *A. dispersus* is an invasive species first reported to occur in India in 1995 on a variety of plants (David and Regu, 1995; Palaniswami *et al.*, 1995). Srinivasa (2000) reported that in India it is known to attack 253 plant species.

Diversity of longicorn beetles (Coleoptera: Cerambycidae) of Amba Reserved Forest, Western Ghats, Maharashtra

S. R. Aland[1], A. B. Mamlayya[1], S. M. Gaikwad[2] and G. P. Bhawane*[1]

[1]*Department of Zoology, Shivaji University, Kolhapur, Maharashtra, India*
[2]*Department of Zoology, Bhogawati Mahavidyalaya, Kurukali Dist, Kolhapur, India*
Email: drgpbhawane@rediffmail.com

ABSTRACT: Diversity of longicorn beetles of Amba Reserved Forest of Western Ghats, Maharashtra was investigated. A total of 17 species of longicorn beetles belonging to 16 genera and three subfamilies were collected. Of these, *Batocera rufomaculata* DeGeer. *B. numitor* (Newm.), *Celosterna scabrator* (Fb.), *Olenocamptus bilobus* (Fb.), *Pterolophia* sp., *Xystocera globosa* Oliv., *Aeolesthes holosericea* Fb., *Priotyrannus mordax* (White) and *Stromatium barbatum* Fb., are common while *Coptops aedificator* (Fb.), *Acalolepta nivosa* (White), *Glenea multiguttata* (Guerin-Meneville), *Stibara nigricornis* Fb., *Thylactus angularis* Pascoe, *Xylotrechus subscutellatus* Chevr., *Nyphasis apicalis* Gahan and *Acanthophorus serraticornis* Oliv. are rare species. © 2010 Association for Advancement of Entomology

KEYWORDS: species diversity, Cerambycidae, Western Ghats

The Western Ghats are known to harbour rich biodiversity and is approved as one of the 25 biodiversity hot spots of the world. It occupies a critical position in the global biodiversity scene (Myers *et al.*, 2000).

The family Cerambycidae (Order Coleoptera) includes large insects which are readily recognizable from their general form and long antennae. They are principally confined to forest areas. Gahan (1906) listed 309 species from Indian region and most of our knowledge about their diversity is largely based on earlier studies by pioneer workers like Hampson (1896–1899). Although a series of revisionary studies have been subsequently carried out from different geographical regions, no exhaustive survey has so far been made specifically from the various forests. This is particularly true with regard to the Western Ghats region (Mathew and Rahamthulla, 1995). Therefore an attempt was made to study the diversity of longicorn beetles of Amba Reserved Forest of Western Ghats, Maharashtra.

*Corresponding author

TABLE 1. Longicorn beetles collected from Amba Reserved Forest, Western Ghats, Maharashtra

Family Cerambycidae
Sub family Lamiinae
Batocera rufomaculata De Geer
B. numitor (Newm.)
Celosterna scabrator (Fb.)
Coptops aedificator (Fb.)
Olenocamptus bilobus (Fb.)
Acalolepta nivosa (White)
Pterolophia sp.
Stibara nigricornis Fb.
Glenea multiguttata (Guerin-Meneville)
Thylactus angularis Pascoe
Sub family Cerambycinae
Xystocera globosa Oliv.
Aeolesthes holosericea Fb.
Xylotrechus subscutellatus Chevr.
Nyphasia apicalis Gahan
Stromatium barbatum Fb.
Sub family Prioninae
Acanthophorus serraticornis Oliv.
Priotyrannus mordax (White)

Amba Reserved Forest is situated in North–West direction of Kolhapur district which lies between 15° to 17° N and 73° to 74° E latitudes in south Maharashtra State. It is a tropical semi-evergreen forest and covers an area of 318.16 ha. The average rainfall of this region is 2000 mm. Temperature during summer, winter and rainy seasons ranges from 20–38 °C, 10–30 °C and 15–30 °C, respectively.

The longicorn beetles were collected in 2008 by undertaking frequent field visits to Amba Reserved Forest at an interval of one month. Swipe method, hand picking and fluorescent light trap method were used for collection.

Altogether 17 species of longicorn beetles belonging to 16 genera and three subfamilies were collected and identified (Table 1). The subfamily Lamiinae contained the maximum of ten species, followed by Cerambyciinae with five species and Prioninae with two species. The study indicated that the Cerambycidae of Amba Reserved Forest is rich and diversified. Maximum number of beetles was recorded in rainy season compared to winter and summer.

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Relative toxicity (LC_{50} and LT_{50}) of some organophosphate insecticides used against the rice bug, *Leptocorisa acuta* Thunb. (Hemiptera: Coreidae)

V. S. Revathy and C. F. Binoy*

*Research & PG Department of Zoology, St. Thomas College, Thrissur, Kerala, India
Email: cfbinoy@rediffmail.com*

ABSTRACT. Laboratory bioassay of four commonly used organophosphate insecticides against the rice bug, *Leptocorisa acuta* Thunb showed that dimethoate was the best, followed by triazophos, profenofos and chlorpyrifos.
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KEYWORDS: *Leptocorisa acuta*, rice bug, organophosphates, toxicity

Paddy (*Oryza sativa*) is one of the major staple crops of the world and among the major pests of paddy, the rice bug *Leptocorisa acuta* Thunb (Hemiptera: Coreide) is a destructive sporadic pest sometimes causing total loss of crop (Srivastava and Saxena, 1960). Hence effective measures are required to control this pest and several insecticides are in use (Krishnakumar and Visalakshi, 1989). Comparative benefits of these insecticides are lacking and hence a laboratory evaluation of the organophosphate insecticides commonly used in the field was done. A comparative evaluation of the cost of the insecticides is also made.

Adults of *L. acuta* collected from unsprayed paddy fields were used. Four organophosphate insecticides were compared, namely triazophos, profenofos, dimethoate and chlorpyrifos. Graded concentrations of the emulsifiable concentrate of the insecticides were prepared and fresh rice earheads at milky stage collected from field were sprayed with each dilution using 5 ml per earhead and placed in a glass tube containing water which was further kept in a cylindrical glass jar and closed with muslin cloth. After 20 min, 20 adult rice bugs were released into the jar and mortality was recorded every 1 h, up to 48 h after treatment. Three replications were set up for each treatment and control. The data were subjected to Probit analysis (Finney, 1973; Busvine, 1971) to obtain LC_{50} and LT_{50} values.

*Corresponding author

TABLE I. Relative toxicity of insecticides commonly used against *L. acuta*

Insecticide	Heterogeneity	Regression equation	LC_{50}	Fiducial limits	Relative toxicity	Order of Relative Efficacy	Relative LT_{50}
Triazophos	$\chi^2(13)$ 13.102	$Y = 0.58083 + 26.00562x$	0.02233	0.00831–0.3188	1.91	2	6.5
Dimethoate	$\chi^2(13)$ 5.210	$Y = 0.39994 + 20.54804x$	0.01946	0.00027–0.03139	2.19	1	6.2
Profenofos	$\chi^2(13)$ 10.728	$Y = 0.67800 + 19.65919x$	0.03449	0.1978–0.04560	1.24	3	9.3
Chlorpyrifos	$\chi^2(13)$ 9.299	$Y = 0.59512 + 13.96197x$	0.04262	0.02284–0.05799	1	4	8.2

TABLE 2. LT$_{50}$ of insecticides commonly used against *L. acuta* infesting rice

Insecticide	Concentration (%)	Heterogeneity	Regression equation	LT$_{50}$	Fiducial Limits	Mean LT$_{50}$	Order of Relative Efficacy
Triazophos	0.01	χ^2(13) 5.712	$Y = 1.76450 + 0.12839x$	13.7	10.98–20.63		
	0.025	χ^2(13) 8.875	$Y = 1.33974 + 0.20416x$	6.5	5.42–7.85		
	0.05	χ^2(13) 14.110	$Y = 0.91603 + 0.24016x$	4.8	2.75–4.81	6.02	2
	0.075	χ^2(13) 14.817	$Y = 0.74943 + 0.18703x$	4.0	2.64–5.21		
	0.1	χ^2(13) 7.155	$Y = 0.45865 + 0.40773x$	1.1	0.31–1.83		
Dimethoate	0.01	χ^2(13) 11.927	$Y = 1.97691 + 0.19589x$	10.2	8.70–12.19		
	0.025	χ^2(13) 8.537	$Y = 2.30474 + 0.36552x$	6.2	5.52–7.20		
	0.05	χ^2(13) 17.772	$Y = 2.19462 + 0.40812x$	5.3	4.66–6.19	5.72	1
	0.075	χ^2(13) 10.129	$Y = 1.80698 + 0.40763x$	4.4	3.75–5.21		
	0.1	χ^2(13) 21.395	$Y = 1.03462 + 0.39953x$	2.5	1.44–3.61		
Profenofos	0.01	χ^2(13) 5.153	$Y = 2.86994 + 0.30245x$	9.4	8.48–10.67		
	0.025	χ^2(13) 13.621	$Y = 2.15035 + 0.23082x$	9.3	8.04–11.15		
	0.05	χ^2(13) 9.437	$Y = 2.06076 + 0.27520x$	7.4	6.50–8.62	6.8	3
	0.075	χ^2(13) 6.498	$Y = 1.86465 + 0.35162x$	5.3	4.49–6.22		
	0.1	χ^2(13) 5.942	$Y = 1.51581 + 0.58034x$	2.6	2.09–3.31		
Chlorpyrifos	0.01	χ^2(13) 24.394	$Y = 2.16213 + 0.16605x$	12.6	9.85–22.21		
	0.025	χ^2(13) 14.595	$Y = 2.09425 + 0.19823x$	10.5	9.12–12.79		
	0.05	χ^2(13) 16.571	$Y = 1.44268 + 0.17425x$	8.2	6.91–10.11	7.8	4
	0.075	χ^2(13) 11.665	$Y = 0.58963 + 0.11985x$	4.9	2.55–6.89		
	0.1	χ^2(13) 10.679	$Y = 0.43788 + 0.15412x$	2.8	0.72–4.32		

Based on LC_{50} values the toxicity of dimethoate was found to be the highest, followed by triazophos, profenofos and chlorpyrifos (Table 1). Mean LT_{50} value also was found to be least for dimethoate, followed by triazophos, profenofos and chlorpyrifos (Table 2). At the current market price, the insecticides could be ranked as chlorpyrifos (Hilban, Rs. 203/l) < dimethoate (Rogor, Rs. 342/l) < profenofos (Cypro, Rs. 380/l) < triazophos (Tarzan, Rs. 432/l). Use of dimethoate appears to be more beneficial on the basis of effectiveness and cost.

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Developmental biology of Carmine Spider Mite, *Tetranychus cinnabarinus* Boisduval (Prostigmata: Tetranychidae) infesting marigold

Puja Rani[1,2] and Vinay Kumar Jandial[*1]

[1] *Department of Entomology and Apiculture, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230, India Email: vinay_eap06@yahoo.co.in*
[2] *Central Potato Research Institute, Shimla, Himachal Pradesh 171 002, India*

ABSTRACT: The biology of Carmine Spider Mite, *Tetranychus cinnabarinus* Boisduval on marigold was studied under laboratory conditions at 21–27 °C, and 50%–60% RH in Solan, Himachal Pradesh, India during April to June 2003. The life cycle did not show any remarkable variation from those observed on plants like okra, brinjal and ornamental plants grown in different parts of the country. © 2010 Association for Advancement of Entomology

KEYWORDS: biology, Carmine Spider Mite, marigold, *Tetranychus cinnabarinus*

Carmine Spider Mite, *Tetranychus cinnabarinus* Boisd. (Prostigmata: Tetranychidae) is a polyphagous pest and its development has been studied on different crops viz. brinjal, okra, tomato, cucurbits, cotton, etc. (Singh and Singh, 1993). Marigold is a crop gaining importance in Himachal Pradesh and *T. cinnabarinus* has become a serious pest of this crop. In view of the commercial significance of this crop, the biology of Carmine Spider Mite was studied so as to provide clues on the time and type of control measures to be adopted.

For observations on development, the initial culture of *T. cinnabarinus* was raised on potted marigold plants in the laboratory using male and female mite collected from the field. They were reared on medium sized compound leaves of marigold placed on wet blotting paper kept in Petri dishes. Male and female mites were transferred to dishes and after the females laid their first batch of eggs they were removed from the dishes. These eggs were reared individually up to the completion of life cycle. Data on pre-oviposition, oviposition and post-oviposition periods as well as duration of various life stages of *T. cinnabarinus* were recorded. From this data different biological parameters were calculated and are presented in Table 1.

*Corresponding author, Present address: Ward No. 6, House No. 40, Ramnagar, Distt. Udhampur, Jammu & Kashmir 182 122, India

TABLE 1. Biological parameters of *T. cinnabarinus* under laboratory conditions

Parameter	Duration/Value	
	Mean	Range
Egg		
Incubation period (d)	4.91	4.6–5.5
Larva	1.28	1.21–1.35
Nymph		
Protonymph (d)	1.49	1.34–1.60
Deutonymph (d)	1.56	1.35–1.75
Adult		
Pre-mating period (s)	33.50	25.0–40.0
Mating period (s)	63.40	50.0–85.0
Pre-oviposition period (d)	1.50	1.0–2.5
Oviposition period (d)	4.60	4.0–5.5
Post-oviposition period (d)	9.10	8.0–10.0
Adult longevity		
Male (d)	11.20	10.5–12.0
Female (d)	15.20	13.5–15.5
Total life span (egg to adult)		
Male (d)	20.50	18.99–20.80
Female (d)	24.46	21.99–25.70
Fecundity (eggs/female)	51.50	–
Sex ratio (male : female)	1:5.5	–
Hatchability (%)	80.97	–

The values are based on 10 replications.

The results showed that *T. cinnabarinus* passed through five stages viz., egg, larva, protonymph, deutonymph and adult, as recorded previously (Hessein, 1997; Bhagat and Singh, 1999; Baradaran *et al.*, 2001).

Eggs were laid on the lower surface of leaves in the web made by adults. The incubation period varied from 4.6 to 5.5 d with an average of 4.91 d. Bhagat and Singh (1999) observed a mean incubation period of 5.6 ± 1.14 d.

The total larval period varied from 1.21 to 1.35 d with an average of 1.28 d. The duration of larval period on okra varied between 1.22 to 1.70 d (Rishi *et al.*, 1996). Before moulting to protonymph, larvae became quiescent for 3 to 7 hours. Baradaran *et al.* (2001) also reported that *T. cinnabarinus* has three developmental stages viz. larva, protonymph and deutonymph interrupted in between with a quiescent stage.

The duration of protonymphal stage varied from 1.34 to 1.60 d with an average of 1.49. Rishi *et al.* (1996) also reported that protonymphal period varied from 1.23 to 1.59 d when reared on ornamental plants. After a short quiescent stage having a transparent covering, they moulted as deutonymph. At deutonymphal stage, sexes were quite distinct. The male was smaller and has posteriorly pointed abdomen with bright orange colouration. Deutonymphal period varied from 1.35 to 1.75 d with an

average of 1.56. The deutonymphal period of the mite was reported as 1.5 to 3 d on okra (Hessein, 1997) and 2.00 to 3.02 d on brinjal (Rishi *et al.*, 1996). The premating period varied from 25 to 40 s with an average of 33.50. Newly moulted adult males were seen waiting for the emergence of female from the quiescent deutonymph. Only one male was successful to crawl beneath the female and bend abdomen upon the back for mating. Adult female was seen mating with 2–3 males successively. The duration of mating period ranged from 50 to 85 s with an average of 63.4 s.

The pre-oviposition, oviposition and post-oviposition period varied from 1.0 to 2.5, 4.0 to 5.5 and 8.0 to 10.0 d, with an average of 1.5, 4.6 and 9.1 d, respectively. According to Rishi *et al.* (1996), the corresponding periods were 2.0, 2.3 and 8.8 d, respectively. However, the oviposition period of *T. cinnabarinus* reported by Huang and Zhang (1989) on mulberry was 21.25 d, much higher than that observed on marigold. Witul and Kiekiewicz (1998) observed that bionomics of *T. cinnabarinus* depends greatly on the host plant species and cultivar.

The longevity of male varied from 10.5 to 12.0 d with an average of 11.2 d, while that of female varied from 13.5 to 15.5 d with an average of 15.2 d. Rishi *et al.* (1996) reported that the longevity of male and female were 9.6 and 13.10 d, respectively. The life span of *T. cinnabarinus* was completed in 18.99 to 20.80 d with an average of 20.5 d in case of male, whereas it was 21.99 to 25.70 d with an average of 24.46 d in case of female. Contrary to the present findings, Hessein (1997) reported that the life span of *T. cinnabarinus* on citrus was 21.8 d for females and 32.89 d for males.

Average fecundity was 51.5. Bhagat and Singh (1999) reported that a female laid 59.8 eggs when reared on brinjal and Rishi *et al.* (1996) found that the fecundity was 24.8 when reared on okra. The results show that the host plant influences the fecundity of the mite significantly and marigold is as good a host as many others. The sex ratio (male: female) was found to be 1: 5.5 which was more favorable than the ratio on okra (1: 2.19) reported by Rishi *et al.* (1996). The hatching percentage observed in the present study was 80.97 whereas Rishi *et al.* (1996) reported 77.3 per cent for those reared on okra.

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Novak V. J. A. (1966) *Insect Hormones*. Methuen and Co., 478 pp.

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